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With METALLURGICAL SUPPLEMENT.

The Engineer.

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VOL. CXLV.—No. 3763] LONDON: FRIDAY EVENING, FEBRUARY 24, 1928 [PRICE {WITH SUPPLEMENTS} ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES

The Director-General, India Store Department, Belvedere-road, Lambeth, S.E.1, invites TENDERS for :—
SCHEDULE 1, 1200 HELICAL COIL SPRINGS.
SCHEDULE 2, 2000 BUFFER PLUNGERS.
SCHEDULE 3, 70-KW D.C. STEAM ENGINE-DRIVEN GENERATING SET.
Tenders due on the 13th March, 1928, for Nos. 1 and 2, and on the 30th March, 1928, for No. 3.
Forms of Tender obtainable from the above at a fee (which will not be returned) of 5s. for each schedule. 7849

Assistant Engineers (10) REQUIRED by the GOVERNMENT of NIGERIA for the PUBLIC WORKS DEPARTMENT for two tours of not less than 12 nor more than 18 months' service in the first instance. Subject to satisfactory service the officers appointed will be eligible at the expiration of three years' service for confirmation in the permanent and pensionable establishment. Salary £480, rising to £920 a year. Outfit allowance of £60 on first appointment. Free quarters and passages and liberal leave on full salary. Candidates, preferably between 25 and 35 years of age, must have passed the examination for A.M.I.C.E. or possess a degree in civil engineering recognised by the Institution as exempting from Parts "A" and "B" of the examination. Must have had proper technical training and preferably have had not less than two years' subsequent experience on large Engineering or Municipal Works.—Apply at once by letter, stating age, qualifications and experience, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting M/254. 7748

Assistant Engineers Required for the PUBLIC WORKS DEPARTMENT of the FEDERATED MALAY STATES for four years' service, after which, subject to satisfactory service, the officers appointed will be eligible for confirmation in the permanent and pensionable establishment. It is probable that the number of permanent appointments will be sufficient for those officers whose services have been entirely satisfactory, but no guarantee can be given. If at the end of four years' service an officer's services have been entirely satisfactory and he is not offered or declines further employment he will be paid a bonus of 2850 dollars. Salary 400 dollars a month, rising to 800 dollars by annual increments of 25 dollars, plus a temporary non-pensionable allowance of 10 per cent. for bachelors and 20 per cent. for married men. The exchange value of the dollar in sterling is at present fixed by the Government at 2s. 4d., but its purchasing power in Malaya is considerably less than that of 2s. 4d. in the United Kingdom. No income tax at present imposed by the Federated Malay States Government. Free passages provided. Candidates, age 22 to 26, preferably unmarried, must have received a good theoretical training, preferably at a University or College recognised by the Institution of Civil Engineers, and possess a Civil Engineering Degree or obtain such other diploma or distinction in engineering as the Secretary of State may decide in any particular case, or have completed articles with a civil engineer of good standing and have passed the examination for Associate Membership of the Institution of Civil Engineers. In addition candidates must have had at least one year's practical experience of civil engineering under a qualified civil engineer.—Apply at once by letter, giving brief details of qualifications and experience, and stating age and whether married or single, to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, Westminster, S.W.1, quoting clearly at the head of application M/15224. 7762

Civil Engineer Required by the GOVERNMENT of the BAHAMAS for the Waterworks and Sewerage Department for three years' service, and possible extension. Salary £800 a year with the prospect of rising to £1000 a year after about one year's service. Free passages. Candidates, between 32 and 36 years of age (an abatement of the age limit is allowed on account of war service), must have passed examination for A.M.I.C.E. or possess a Degree in Civil Engineering recognised by the Institution as exempting from Parts A and B of the examination. Must have had at least 8 years' practical experience on Waterworks and Sewerage Construction and Maintenance, of which at least five years should have been in the Colonies. Must have a knowledge of Waterworks Management, the Maintenance of Pumping Stations, Reservoirs, Water Softeners, Chlorinating Plants, Water Towers, Water Mains, House Connections and Meters. Must also have a knowledge of Working of Sewers, Ejector Stations, Sedimentary Tanks and Activated Sludge Plant.—Apply at once by letter to the CROWN AGENTS FOR THE COLONIES, 4, Millbank, S.W.1, stating age, qualifications and particulars of experience and quoting M/443. 7799

Indian Service of Engineers. The Secretary of State for India in Council will, in 1928, APPOINT NINE ASSISTANT EXECUTIVE ENGINEERS for this Service, including, if possible, ONE BURMAN, who will be appointed to the India recruited branch in Burma. Except for this one appointment, every candidate must be a European British subject of non-Asiatic domicile.
Candidates must have attained the age of 21 years and must not have attained the age of 24 years on 1st January, 1928.
They must either (1) have obtained one of certain recognised University Degrees or other distinctions in engineering, or (2) have passed Sections A and B of the Associate Membership Examination of the Institution of Civil Engineers or been exempted by the Institution from such examination, or (3) have passed the Associateship in Civil Engineering of the City and Guilds Institute (Imperial College of Science and Technology, South Kensington), or (4) produce the required evidence that they are otherwise eligible under the Regulations. They must in addition have had at least one full year's practical experience of Civil Engineering under a qualified Civil Engineer.
Applications from candidates must reach the India Office not later than 1st April, 1928. Printed forms, together with information regarding the conditions of appointment, may be obtained from the SECRETARY, Services and General Department, India Office, Whitehall, S.W.1. 7339

The Engineer

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PUBLIC NOTICES

Bombay, Baroda and Central India Railway Company.
The Directors are prepared to receive up to Noon on Wednesday, 14th March, TENDERS for the SUPPLY of :—
GRINDING MACHINES.
Tenders must be made on forms, copies of which, with specification, can be obtained at these offices on payment of 10s. each, which will not be returned.
The Directors do not bind themselves to accept the lowest or any Tender.
S. G. S. YOUNG, Secretary.
Offices : The White Mansion, 91, Petty France, S.W.1.
20th February, 1928. 7817

Metropolitan Water Board.
TENDER FOR DIVERSION OF MAINS—BEVERLEY BRIDGE.
The Metropolitan Water Board invite TENDERS for DIVERTING their existing 36in., 30in., 24in., and 15in. diameter MAINS at Beverley Bridge, Kingston Vale, together with the LAYING of a SHORT LENGTH of 21in. diameter MAIN in the Portsmouth Road.
The drawings, conditions of contract and specification may be inspected without charge at the offices of the Board, Chief Engineer's Department (Room 201), on and after Monday, 27th February, 1928, and may be obtained, together with forms of Tender, on the production of an official receipt for the sum of £2, which must be deposited with the Accountant to the Board and which will be returned on receipt of a bona fide Tender accompanied by all the above-named documents and drawings. Such payments and applications must be made between the hours of 10 a.m. and 4 p.m. (Saturdays, 10 a.m. and 12 noon). Cheques must be made payable to the Metropolitan Water Board and not to individuals.
Tenders, enclosed in sealed envelopes addressed to the Clerk of the Board and endorsed "Tender for Diversion of Mains, Beverley Bridge," must be delivered at the offices of the Board, Room 122, not later than 10 a.m. on Monday, 12th March, 1928.
The Board do not bind themselves to accept the lowest or any Tender.
G. F. STRINGER, Clerk of the Board.
Offices of the Board, 173, Rosebery-avenue, E.C.1, 20th February, 1928. 7815

PUBLIC NOTICES

South Indian Railway Company, LIMITED.
The Directors are prepared to receive TENDERS for the SUPPLY of :—
ACETYLENE GENERATING PLANT AND ACCESSORIES.
Specifications and forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.
Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked :—Tender for "Acetylene Generating Plant and Accessories," must be left with the undersigned not later than 12 Noon on Friday, the 9th March, 1928.
The Directors do not bind themselves to accept the lowest or any Tender.
A charge, which will not be returned, will be made of 2s. 6d. for each copy of the specification.
A. MUIRHEAD, Managing Director.
91, Petty France, Westminster, S.W.1. 22nd February, 1928. 7851

The Bengal and North-Western RAILWAY COMPANY, LIMITED.
The Directors are prepared to receive TENDERS for the SUPPLY of :—
374 BUFFERS (Loco. Carriage and Wagon).
1850 LAMINATED SPRINGS.
7000 STEEL BOILER TUBES and 10 FLUE TUBES.
444 STEEL TYRES for LOCOMOTIVES.
1500 STEEL TYRES for CARRIAGES and WAGONS,
as per specifications to be seen at the Company's offices.
Tenders, addressed to the undersigned and marked "Tender for Buffers," or as the case may be, with name of firm tendering, to be lodged not later than Noon on Tuesday, the 13th day of March, 1928.
For each specification a fee of 10s. will be charged, which cannot under any circumstances be returned.
The Directors do not bind themselves to accept the lowest or any Tender.
By Order of the Board, W. R. IZAT, Managing Director.
237, Gresham House, Old Broad-street, London, E.C.2, 20th February, 1928. 7816

PUBLIC NOTICES

Royal Show. PRACTICE WITH SCIENCE

NOTTINGHAM
JULY 10th to 14th, 1928.

EXHIBITION OF IMPLEMENTS, &c.
The Regulations and Forms of Application for Space are now ready.
Applications for space must be made by TUESDAY, MARCH 20th, 1928.
ENTRIES for Silver Medal close March 1st.

Live Stock (except Riding and Driving Horses) entries close on MAY 1st; Riding and Driving Horses on MAY 31st; Produce and Forestry on MAY 21st; Flower Show on MAY 30th; Poultry on MAY 31st; Plantations, Home Nurseries, Orchards and Fruit Plantations on MAY 1st.
T. B. TURNER, Secretary.
ROYAL AGRICULTURAL SOCIETY OF ENGLAND, 16, Bedford Square, London, W.C.1. 7801

PUBLIC HEALTH ACT, 1875.
Urban District of Ruislip-Northwood, MIDDLESEX.
CONTRACT NO. 2.
The Urban District Council of Ruislip-Northwood, acting as the Sanitary Authority for the said District, are prepared to receive TENDERS for WORKS of SEWERAGE and SEWAGE DISPOSAL. The works will comprise 226 Yards of 15in. diameter Stoneware and 1715 Yards of 15in. diameter Cast Iron Outfall Sewers, together with all Manholes, Ventilation Columns, &c., Concrete Equalising Tank, Circular Pump Well, Engine and Pump-house, and all Works incidental thereto.
Particulars and specification may be obtained at the offices of the Consulting Engineers, Messrs. Howard Humphreys and Sons, 28, Victoria-street, Westminster, on and from Monday, the 27th of February, until Friday, the 9th of March, between the hours of 10 a.m. and 4 p.m., upon payment of a deposit of Three Guineas, which deposit will be returned upon receipt of a bona fide Tender which is not subsequently withdrawn by the contractor.
The successful tenderer will be required to execute a contract and bond in a form to be prepared by the undersigned.
Tenders must be on the official form, each Tender in a sealed envelope marked "Tender for Eastcote Drainage." Tenders must be accompanied by the general conditions and specification as issued by the Consulting Engineers.
Each Tender must be signed in the handwriting of the tenderer or his authorised agent.
The Council does not bind itself to accept the lowest or any Tender.
Tenders must reach the undersigned by 9 a.m. on Friday, the 30th of March, 1928.
Given under my hand the 22nd day of February, 1928.
EDMUND R. ABBOTT, Clerk to the Ruislip-Northwood U.D.C.
Council Offices, Northwood, Middlesex. 7847

We are Informed of the Formation in Paris of an Association comprising les Ateliers et Chantiers de Bretagne, les Ateliers et Chantiers de la Seine Maritime (WORMS and CIE.), and la Societe Generale de Constructions Mecaniques (Anciens Etablissements E. GARNIER and FAURE BEAULIEU).
This Association has opened at 55, Boulevard Haussmann, Paris, an office from which foreign nations desirous of ordering surface or submarine warships may obtain full information regarding the products of the Association, which are specially applicable to vessels of those classes.
The Association specialises in the construction of turbines operating on the Rateau system, and of Diesel engines of the M.A.N. type. 7821

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PUBLIC NOTICES

Administrative County of LONDON.
DIVISIONAL ENGINEER.

The London County Council invites APPLICATIONS from qualified engineers for the POSITION of an ENGINEER-IN-CHARGE of a division of the Department of the Chief Engineer of the Council. The salary is £700 a year, rising by annual increments of £50 to £900 a year, and is subject to temporary additions, the minimum remuneration being at present about £887 and the maximum about £1101. Candidates must possess recognised qualifications as civil engineers and have occupied positions of responsibility in the conduct of work and the supervision and management of staff. The duties will include the survey and inspection of the river embankments in London and such other duties as may be assigned.

Applications must be made on the official form, copies of which (with full particulars) may be obtained by sending a stamped addressed foolscap envelope, marked "Divisional Engineer," to the Clerk of the Council, The County Hall, Westminster Bridge, S.E. 1. Forms must be returned not later than Friday, 16th March, 1928. Canvassing disqualifies.

MONTAGU H. COX,
7845 Clerk of the London County Council.

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

WANTED for an Important Shipyard, a Sole ASSISTANT OUTSIDE YARD MANAGER; age 35 to 45; must be fully qualified, of varied experience and capable of filling responsible position.—Replies will be treated in strictest confidence.—Address, "SHIPYARD," Wm. Porteous and Co., Advertising Agents, Glasgow. P4208 A

WANTED, Qualified and Experienced CIVIL ENGINEER, to Supervise the Erection of a Large Pontoon Bridge in Kenya Colony, East Africa.—Address, stating age, qualifications, references, and salary, P4199, The Engineer Office. P4199 A

A VACANCY Occurs for a Live MAN for Large Up-to-date Works, capable of designing work in connection with Commercial Vehicles of the high-speed passenger-carrying type.

Only those of exceptional ability and modern ideas of this class of work need apply.

State age, full experience, and salary required to the ASSOCIATED EQUIPMENT COMPANY, Ltd., Windmill-lane, Southall, Mddx. 7846 A

ASSISTANT MECHANICAL ENGINEER, Age 30-35, REQUIRED for POSITION ABROAD in Central Office Controlling Branch Depots. Must have sound technical education and training, with experience of Motor Transport, and capable of administrating this section direct. Preference given to candidate with technical knowledge and practical experience of Petroleum Products.

Good salary paid to competent man.

Write, with three copies of testimonials and giving full particulars of training, to Box L. 65, Willing's, 135, Moorgate, London, E.C. 2. P4203 A

INSPECTOR REQUIRED for Engineering Works in North of England, to look after Inspection of all Incoming Raw Materials, including Light Steel Sections, Small Castings, Stampings, &c., as used in the Metal Window Trade. Applicants must have had similar experience, not necessarily in the window business. The successful candidate will be required to work to instructions of the Chief Inspector.—Address, stating age, experience, and salary required, 7831, The Engineer Office. 7831 A

MANAGER for Aluminium Foundry WANTED by a London Company. Only those who are fully experienced in the making of intricate Castings need apply. Good salary offered.—Address, stating age, details of experience, giving names and addresses of firms and dates of employment, also salary required, 7787, The Engineer Office. 7787 A

MECHANICAL or ELECTRICAL ENGINEERS. Men with University Degrees preferred. Only works managers or assistant works managers with practical and commercial manufacturing experience need apply. Age 28 to 38. High salary.—Address, P4215, The Engineer Office. P4215 A

REQUIRED for London Area, ENGINEER SALESMAN, conversant with Consulting Engineers and Transformer Purchasers.—Address, with full details as to salary, experience, age, &c., 7750, The Engineer Office. 7750 A

SUPERINTENDENT of WORKS REQUIRED, with good practical knowledge of Masonry and other Building Construction. Ferro-concrete Works, Sea Walls, &c. Able to control men, pay wages, make weekly reports, and keep accounts. Must be sober, honest and conscientious. Salary £5 5s. per week. State age, qualifications, and experience, with testimonials.—Address, 7800, The Engineer Office. 7800 A

WORKS MANAGER.—ENGINEER Experienced in Light Steel Stamping Work and Up-to-date Methods of Mass Production. Applicants must give particulars of education and record of subsequent practical experience, also state age and salary required.—Address, P4192, The Engineer Office. P4192 A

WANTED, First-class DRAUGHTSMEN, with Good mechanical and constructional experience and used to Plant Lay-out.—Address, Ref. J.Y.D., 7838, The Engineer Office. 7838 A

WANTED IMMEDIATELY, Competent CRANE DRAUGHTSMAN by Electric Crane Manufacturers in the Manchester district.—Address, 7805, The Engineer Office. 7805 A

WANTED IMMEDIATELY, STRUCTURAL DRAUGHTSMEN. Permanency for right men. Experience in design and detailing of Steel-framed Buildings essential.—Apply, stating age, experience, and salary required, to CHIEF ENGINEER, DREW-BEAR, PERKS and CO., Ltd., Battersea Steel Works, Wellington-road, Battersea, S.W. 11. 7840 A

ASSISTANT CHIEF DRAUGHTSMAN REQUIRED for large Shipbuilding Establishment; must have high qualifications and be competent to Take Charge in absence of chief. Age preferably not over 40. Applications considered strictly as private.—Address, "MARINE," Wm. Porteous and Co., Advertising Agents, Glasgow. P4209 A

DAVID BROWN and SONS, Ltd., Huddersfield, invite APPLICATIONS from first-class leading MACHINE TOOL DESIGNERS. They should be conversant with Gearing and the latest production processes and be capable of working out ideas without supervision. Originality and initiative essential. 7804 A

DRAUGHTSMAN for Switchgear Development, H.T. and L.T. Draw-out Gear, Circuit Breakers, and General Control Gear. Mechanical experience. State age, experience, and salary required. District near London.—Address, 7812, The Engineer Office. 7812 A

DRAUGHTSMAN.—HEATING and VENTILATING DRAUGHTSMAN REQUIRED for the provinces. Good opening for the right man. State age, experience, and salary.—Address, 7844, The Engineer Office. 7844 A

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DRAUGHTSMAN, Preferably Experienced in Design of Sluice Valves and Water Fittings and/or Machine Tools. Salary 65s.—Address in strictest confidence, giving full particulars of age, experience, &c., 7797, The Engineer Office. 7797 A

DRAUGHTSMAN REQUIRED AT ONCE for London office, having experience in Steel Structures and Conveying Machinery.—Address, giving age, experience, and salary required, 7839, The Engineer Office. 7839 A

CHAPMAN & HALL'S TECHNICAL BOOKS

THE DESIGN AND CONSTRUCTION OF DAMS

Including Masonry, Earth, Rock-fill, Timber and Steel Structures, also the principal types of movable dams. By EDWARD WEGMANN, C.E., M. Am. Soc. C.E., with a Mathematical Discussion and Descriptions of Multiple Arch Dams, by F. A. NOETZLI, D.Sc. EIGHTH REVISED AND ENLARGED EDITION. 740 pages, 291 figures, 191 plates. 87s. 6d. net. Since the seventh edition of this treatise appeared in 1922, a number of important masonry dams have been built in various parts of the world. Descriptions of these masonry dams, and of many others, including the Sennar Dam, across the Nile in Egypt, are given in this new eighth revised and enlarged edition. The author obtained his material by searching published records, and in many cases by correspondence with the engineers, who either designed or built the structures. Material has been added on uplift and ice pressure forces which was not taken into account in designing dams prior to the failure of the Bouzey Dam in 1895. To the chapter describing rock-fill dams have been added descriptions of recent structures of this kind. The treatise has now grown to a volume of 740 pages, an increase of 185 pages over the seventh edition. Part IV. in the new edition is devoted to "Multiple Arch Dams." It contains descriptions of dams of this type, written by Fred. A. Noetzli, Consulting Engineer, of Los Angeles, California.

MODERN FOUNDRY OPERATIONS AND EQUIPMENT

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Written by a Staff of 43 Specialists. ROBERT PEELE, Editor-in-Chief. 2523 pages, fully illustrated. 1 Vol. edition 50s. net. 2 Vols. edition, leather, 60s. net. The editor has taken into account the development in engineering practice and the economic results of the Great War, making numerous changes, corrections, and additions. Labour-saving methods and machines are discussed more completely. New information is presented on the replacement of hand tramming by mechanical haulage, the wider use of electricity, and phases of compressed air practice. Cost data have been changed to reliable present-day figures. Of the 44 sections, 12 are almost entirely re-written and 13 are greatly altered.

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ELECTRICAL ENGINEERING ECONOMICS
A STUDY OF THE ECONOMIC USE AND SUPPLY OF ELECTRICITY.

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Please send for list of new Technical volumes.

CHAPMAN & HALL, LTD., 11, HENRIETTA STREET, LONDON, W.C. 2.

SITUATIONS OPEN (continued)

DRAUGHTSMAN REQUIRED for London Flour Mills. Applicants must have had good general experience of Lay-out of Machinery, Power Plant, &c.—Reply, stating age, experience, wages required, by letter only, to "E" Dept., J. and H. ROBINSON, Ltd., Deptford Bridge Mills, Greenwich, S.E. 7807 A

DRAUGHTSMEN REQUIRED by London Constructional Engineers for Detailing Structural Steel Work. Some knowledge of L.C.C. Regulations. Permanency for suitable men.—Address, giving particulars of age, salary, &c., 7825, The Engineer Office. 7825 A

DRAUGHTSMEN REQUIRED, with First-class experience in Water-tube Boiler design and details for land and marine work. Applicants must give full details of past experience, stating age and salary expected, and when able to commence.—Address, 7824, The Engineer Office. 7824 A

DRAUGHTSMAN REQD. With Good Experience in Structural Steelwork in the City. State age, experience, and salary required.—Address, P4217, The Engineer Office. P4217 A

DRAUGHTSMEN WANTED for London Works who have had experience with Printing Presses.—Address full particulars and salary required, 7842, The Engineer Office. 7842 A

DRAUGHTSMAN WANTED for Refrigeration and Centrifugal Pump Work in South of England.—Address particulars of age, experience, and salary expected to 7850, The Engineer Office. 7850 A

DRAUGHTSMAN WANTED for Special Machine Tools. Applications only invited from men of first-class ability.—Address, stating experience, 7775, The Engineer Office. 7775 A

DRAUGHTSMAN WANTED. Must Have Experience in Waste Heat Boilers. State experience and salary required.—Address, 7832, The Engineer Office. 7832 A

JUNIOR DRAUGHTSMAN, Detail Work. Must have practical experience. Address, stating age, wage and experience, P4212, The Engineer Office. P4212 A

METROPOLITAN-VICKERS ELECTRICAL COMPANY, Limited, Trafford Park, Manchester, REQUIRES DRAUGHTSMEN, with experience of Condensing Plant, Evaporators and Re-heaters.—Applications, with particulars of age, experience and salary required, should be addressed to the Company's Employment Department, marked "Condenser Draughtsmen." 7848 A

REQUIRED, SIX First-class AERONAUTICAL DRAUGHTSMEN, with good experience of mechanical detail design; preference given to men with sound technical training.—Reply, giving full particulars age, experience, and salary required, to BLACKBURN AERO. and MOTOR CO., Ltd., Brough, E. Yorks. 7752 A

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For continuation of Small Advertisements see page 4.

A Seven-Day Journal

Wages in the Shipbuilding Industry.

ON Friday of last week, February 17th, a joint conference between the Shipbuilding Employers' Federation and the Federation of Engineering and Shipbuilding Trades Unions took place at Carlisle, at which the six craft unions outside the Federation were also represented. Mr. John T. Batey, the President of the Shipbuilding Employers' Federation, made a full reply to the case for an advance in wages of 10s. for time workers and 15s. for piece-workers, which was presented by the unions at the London conference on January 27th. He pointed out that the tonnage figures for 1927 were swollen by the results of the industrial upheaval in 1926, that new orders were very hard to get, and that prices were still affected by international competition. Both new and repair work had been more plentiful in 1927, but there was still a small margin in favour of continental prices, which would have to be wiped out. The shipbuilding industry, Mr. Batey went on to say, still had 21 per cent. of its men unemployed, compared with a general unemployment figure of 9·8 per cent. for all the industries of the country. Taking all these facts into account, it was impossible, Mr. Batey said, for the employers to concede the application of the unions. The Central Board of the Federation had, however, proposed that if the unions were prepared to agree to their representatives considering jointly with the employers the formation of an index scheme for the automatic regulation of wages, and if they would continue their co-operation in matters arising out of Part I. of the Joint Inquiry Report, the Board would consider whether the Federation could agree to increase, as from a date some months ahead, the restored bonus of 7s. granted by the court of arbitration in 1924 up to 10s. in the case of time workers. The employers suggested that, having regard to the high level of earnings among piece workers, and the present circumstances of the industry, they could not grant any increase of bonus to men paid by results, or on other than plain time rates. The offer made by the employers is being considered by the unions.

The Chamber of Shipping.

THE fifty-first annual meeting of the Chamber of Shipping of the United Kingdom took place on Wednesday, February 22nd, when the new President, Sir William Seager, gave his address. Sir William is very closely connected with the port of Cardiff and also with the North of England, and his optimistic outlook is based on actual knowledge of shipping and shipbuilding matters. He suggested that confidence and co-operation were at present required, and that with the knowledge that we were building thoroughly up-to-date tonnage for both cargo and liner work, we could hope for a steady improvement in the shipping industry. If the figures for new tonnage added during the past year were examined, it was shown, said Sir William, that the new ships commissioned only just made up the amount of wastage through losses and breaking up. British ships still carried half the trade of the world, and although the comparatively high proportion of ships over twenty years of age was steadily being reduced by the present building programme, it was significant that more than half the ships of the British mercantile marine were under ten years old. The annual report of the Chamber deals fully with all factors relating to the national, economic and shipping positions, and some valuable statistics are given. We observe that the rapid development of the motor ship and the use of pulverised fuel do not pass unnoted. On Thursday evening, February 23rd, the annual dinner of the Chamber was held at the Guildhall, and the guest of honour was H.R.H. the Prince of Wales, Master of the Merchant Navy and Fishing Fleets.

A Transatlantic Wireless Demonstration.

TRANSATLANTIC wireless telephony has made rapid strides. Early in 1923 an experimental transmitting plant was set to work in America, and on the night of January 15th of that year we listened at New Southgate to speeches made in New York City. Subsequently, the British Post Office established a transmitting station at Rugby, and a two-way Transatlantic telephone system between Great Britain and America was put into operation in January of last year. On March 7th, 1927, we were permitted to test the service, which left little, if anything, to be desired. The latest development is the use of the system for holding joint meetings. On Thursday afternoon of last week, February 16th, members of the Institution of Electrical Engineers in London and those of the American Institute of Electrical Engineers in New York held a meeting of this nature, when speeches made in America were heard in London and those made in London were heard in New York, without the least difficulty. After a film, entitled "Voices Across the Sea," had been shown at the London headquarters of the Institution of Electrical Engineers, and an explanation had been given of the arrangements in New York, Mr. Charlsworth, speaking in that city, asked Colonel Lee in London if Mr. Page, the President of the Institution of Electrical Engineers, was ready to talk. Mr. Gherardi, in New York, then called upon Mr. Page, in London, to act as chairman to the joint meeting. After Mr. Page had made a short speech, Mr. Gherardi replied, and subsequently Mr. Page responded. Dr. Jewett, one of the Vice-presidents of the American Telephone and Telegraph Company and a Past-president of the Institute of Electrical Engineers, then addressed the meeting, and was followed by Colonel Purves in London. General J. Carty, another Vice-president of the American Telephone and Telegraph Company and a Past-president of the American Institute of Electrical Engineers, was the next speaker. He put a resolution to the meeting. This was seconded by Sir Oliver Lodge in London, and after the motion had been put to the meeting by Mr. Page and had been carried unanimously, the proceedings were brought to a close. Two loud speakers were used at each end of the system, and the speeches in London were delivered in the Council Chamber.

An Improved Express Service for East Anglia.

THE directors of the London and North-Eastern Railway Company announce that a new scheme for improving the East Anglian express service of the company has been begun and is to be completed before the end of the year, and that it will involve an expenditure of close upon £250,000. Twenty new engines and thirty new carriages have been ordered, and it is expected that at least ten of the new engines will be ready for the summer traffic. The new coaches will all be of the latest vestibule type, and will make up two new trains, each of twelve coaches, complete with restaurant and kitchen cars, along with a reserve of six coaches. In general, the new stock will closely resemble that which is used on the express trains now running between King's Cross and Yorkshire. As the new engines are to be capable of running at speeds up to 80 miles per hour, and together with the tender will each weigh close upon 100 tons, special work is being undertaken to renew and overhaul the running track and to strengthen the bridges, so that the minimum number of speed restrictions will be necessary during the heavy traffic periods of the spring and summer holiday months. In common with other parts of the line, the East Anglian track has suffered from the heavy rains of the last two months, which have given rise to flooding in some parts, and efforts are to be made to expedite the work of renewal, so that the new programme can be carried out to time.

Fate of the U.S Naval Programme.

PUBLIC opinion in the United States appears to have revolted against the colossal naval shipbuilding programme which was introduced last December, and which has since been under investigation by the Naval Committee of the House of Representatives. According to the latest advices from Washington, there is no longer any prospect of this measure being passed by Congress in its original form. Authority was sought, it will be recalled, for the construction of twenty-five 10,000-ton cruisers, five 13,500-ton aircraft carriers, nine destroyer leaders, and from thirty-two to thirty-five submarines at an estimated total cost of £148,000,000, the whole of this tonnage to be laid down within the next five years. In the absence of any visible menace to the United States, the authors of the programme were constrained to justify their demands on the ground that the growing volume of foreign trade called for adequate protection, and upon being pressed to name the potential aggressor, they hinted, more or less broadly, at Great Britain as the future "enemy," thereby stultifying their own assurance that the measure was in no sense competitive or aimed against any particular nation. It was further revealed in the course of the Committee hearings that this programme was only the first instalment of a grandiose scheme of naval expansion, which could have no other objective than the absolute supremacy of the United States Navy. Admiral Hughes, the Chief of Naval Operations, declared that an extra £50,000,000 would be necessary to provide "adequate security," and other witnesses testified that the plan would involve an addition of nearly 30,000 to the *personnel*. These figures have so impressed the American taxpayer that both the White House and the two Chambers of Congress have been deluged with protests. The programme has already been drastically curtailed, and it is anticipated that the legislative bodies will now be asked to vote funds for the building of fifteen cruisers only, at the rate of three per year. The other fifty-six vessels may be dropped entirely.

The Southern Railway's Electrified Lines.

AT the annual general meeting of the Southern Railway, held on February 21st, the chairman, Brig.-General the Hon. Everard Baring, stated that the money which the company had expended on the electrification of its lines had already returned a handsome profit, and that success had followed the opening of each stage. The improved system of working had enabled the company to deal with an immense increase in traffic, an increase which could not possibly have been handled by means of steam trains. The number of passengers carried in the electrified area was still going ahead by leaps and bounds. That number had increased by 7,250,000 as compared with 1925, in spite of the fact that the opening of the City and South London tube to Morden had deprived the company of about 4,000,000 passengers during the year. The extensions of the electrified services to Guildford, Dartford, Orpington and Sutton had been brought into use partly in 1925 and partly in 1926. The expansion of receipts in those areas, although 1927 was only the second year of electric operation, had been no less than £257,000.

The Institute of Marine Engineers.

AT the annual meeting of the Institute of Marine Engineers, which was held on Friday evening of last week, February 17th, Sir Alan G. Anderson, K.B.E., was elected President of the Institute for the forthcoming session. Sir Alan, who will deliver his presidential address in September next, is widely known in shipping and shipbuilding circles. As a director of Anderson, Green and Co., Ltd., the managers of the Orient Line to Australia, he has been closely identified with the construction of the fine new 20,000-ton liners of the "Orama" class, which have been built for the Orient Line service by Vickers Ltd., at Barrow. The latest vessel, the "Orford," is now approaching completion at her builders' yard, and will undergo trials in the course of the next month or so. Sir Alan Anderson is a past-President of the Chamber of Shipping of the United Kingdom, and is also a Vice-president of the International Chamber of Commerce. The retiring President of the Institute of Marine Engineers is Engineer-Captain Onyon, M.V.O., R.N. (Ret.), who took the chair at the annual meeting. Other changes in office include several elections to the Council of the Institute, and the election of Engineer-Captain H. A. Brown, R.N., of the staff of the Engineer-in-Chief of the Fleet, as a Vice-president and Admiralty representative. Engineer-Rear-Admiral W. M. Whayman has been elected a Vice-president for the London area, in succession to the late Sir James Kemnal.

A 20,000 Kilowatt Turbo-Generator Set for Stockport.

AFTER several hours' discussion, the Stockport Town Council recently decided by 28 to 26 votes to rescind the resolution passed at a previous meeting to accept a Swiss tender amounting to £34,307 for a 20,000-kilowatt set for the electricity works, and to issue fresh advertisements to a specification drawn up by the electrical engineer and approved by the Electricity Committee. When the matter was previously before the Council, the lowest British tender was £52,000, but an offer was subsequently made to carry out the work for £42,000, and in view of this fact the Mayor was requested to call a special meeting of the Council to consider the question of letting the contract. In an amendment to the resolution, Sir Thomas Rowbotham contended that as the tenders for the 20,000-kilowatt set were by the express direction of the Council obtained by competition open to the world, and not confined to British firms, the Council could not go back on its original decision without a complete surrender of its honour, dignity and sense of fair-play, and at the same time without doing gross injustice to the firm that had been led to believe that it had secured the contract. The amendment was, however, defeated by 30 to 28 votes, and at the conclusion of the meeting Sir Thomas Rowbotham resigned his position on the Council.

A Record Flight.

ON February 7th, Mr. Bert Hinkler left Croydon Aerodrome on an Avro "Avian" light aeroplane fitted with a "Cirrus" 30–80 horse-power engine, on an attempt to fly to Australia single-handed and in record time. He fully succeeded in all his objects, for he landed at Port Darwin in the Northern Territory of Australia on February 22nd, just fifteen days after leaving England. The journey was accomplished in fifteen stages, each of which was made without a stop, the longest of which was the 1150-mile lap from Croydon to Rome, and the shortest the succeeding lap of 450 miles from Rome to Malta. The total distance flown was approximately 11,000 miles, and the actual time spent in the air was about 130 hours. The journey was accomplished without incident, and on arrival at Port Darwin the pilot, the machine and the engine were alike in excellent condition. The flight is undoubtedly one of which Mr. Hinkler, the builders of the machine (A. V. Roe and Co., Ltd.), and the makers of the engine (A.D.C. Aircraft, Ltd.), can well be proud. It in no way, of course, detracts from the merits of the pioneer Australian flight by the late Sir Ross Smith and his brother Sir Keith Smith, who performed the journey in 1919 on a Vickers machine in twenty-eight days. Mr. Hinkler's flight is not only the quickest flight to Australia, but establishes the first non-stop flight from London to Rome, the fastest flight from England to India, the longest single-handed flight ever made, and the longest flight ever accomplished on a light aeroplane.

A 1750 B.H.P. Six-cylinder Heavy-Oil Engine.

In a Journal Note published in our issue of November 18th last we referred briefly to the 1200-kW oil engine driven generator set which was put to work on the preceding day at the Short's Gardens Station of the Charing Cross Electric Supply Company, Ltd. The complete installation, it will be recalled, was supplied by the General Electric Company, Ltd., of London, and the engine was designed and built at its Fraser and Chalmers Engineering Works, Erith. In the article which follows a complete account of the origin of the design, its principal technical features, together with details of the engine performance is given. Particular interest attaches to this engine at the present time in view of the much-discussed question of the use of Diesel engines for peak load service in power stations, for it is the largest unit of all-British design and construction which has yet been installed in a power station.

The Origin of the New Design.

It is well known that the General Electric Company, Ltd., has for many years been associated with the construction and development of the steam turbine for industrial and power station purposes. The turbines are built at the Fraser and Chalmers' Erith works of the company, where at the present time units with a capacity of 30,000 kW are under construction. Alongside this line of development, the company has always been interested in the oil engine as a power-producing unit. In 1913 Fraser and Chalmers were negotiating for the manufacture of an oil engine of a continental type at Erith, but the war modified the plan and during the period 1914 to 1918 submarine oil engines of the Vickers type were produced. At the termination of the war the company decided to design and manufacture a new type of heavy oil engine, which would meet the demand for a certain range of powers for use in central stations for peak load service, and in circumstances in which the oil engine would show an economy over steam plant of similar power. An engine of not less than 250 B.H.P. output per cylinder, at normal full load rating, with an overload capacity of 20 per cent., was proposed. In undertaking this task it was further decided to make some radical departures from existing practice, mainly in the direction of higher mean indicated pressures, increased revolutions, the use of cylinder liners of toughened steel, the use of forged steel cylinder heads and of pistons made of aluminium alloys.

These decisions were only come to after a very careful investigation of the heat stresses in the cylinder liner and head and the general conditions of heat transfer. It was wisely decided to make all the parts subjected to combustion temperatures as thin as possible, consistent with ample strength, as the makers were aiming at producing a high-duty and high-power unit which should be free from the troubles at that time caused by subsequent deterioration of iron when used for cylinder covers, piston heads and liners.

The improvements adopted relate to those parts which form the combustion chamber, and which in all internal combustion engines are subjected to very high temperatures, causing expansion of the hot surfaces and setting up considerable heat stresses when these parts are made of iron.

In the General Electric Company's new oil engine, these stresses are kept within small limits. The parts in contact with the hot gases on the one side and with the cooling medium on the other are designed of moderate thickness to eliminate heat stresses by maintaining low temperature differences. Furthermore, these parts are made of metals capable of withstanding high temperatures. It will be observed, as in the case of the cylinder head, that the combustion load is transmitted through the thin combustion plate or hot member to the cold strength member, and that the influence of heat on the thin member in no way interferes with the duty of the strength member.

The makers claim for their engine that the design of the parts subjected to heat brings about a satisfactory solution of the problem of combustion chamber construction, as the method possesses the means of dissipating heat without setting up harmful heat stresses. The departures from orthodox design further gave a lower and lighter engine, occupying a smaller space and needing less costly foundations.

Some Features of the Design.

The first unit to be constructed was a four-cylinder set for dynamo driving, with an output of 750 kW, which was thoroughly tested by Professor Watkinson in November, 1923, and gave very satisfactory results. These results have been substantiated on several three and four-cylinder units which have since been placed in commercial service, both at home and abroad. The following description applies to the first six-cylinder engine constructed by the firm, which we were privileged to inspect during its bench trials, and which, since November last, has been in regular service in the Shorts' Gardens power station of the Charing Cross Electric Supply Company, Limited.

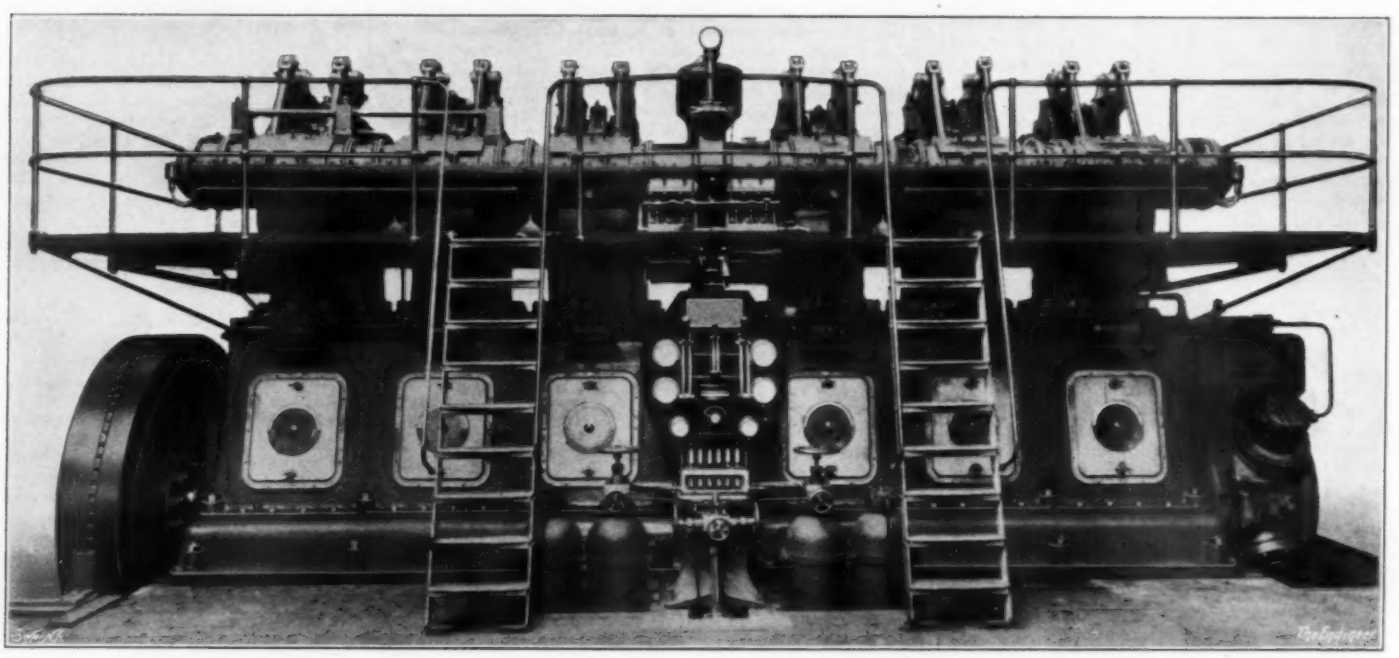


FIG. 1—FRONT VIEW OF 1750 B.H.P. ENGINE SHOWING STARTING CONTROLS

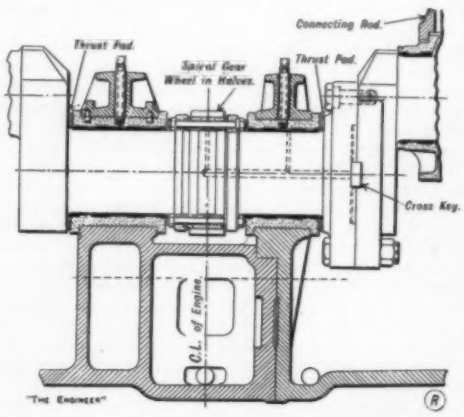


FIG. 2—CRANKSHAFT COUPLING AND GEAR DRIVE

The half-tone engraving, Fig. 1, shows a front view of the engine, with the air injection and starting air receivers and the control board in position, but without the generator. There are six cylinders, each 21½in. bore with a stroke of 22in., with a total designed output of 1750 B.H.P. at 300 r.p.m. Some particulars as to the overall dimensions of the unit may be of interest. The length of the engine and air compressor is only 28ft., with a maximum width of 7ft. 6in. and a height of 12ft. For the withdrawal of pistons only 16ft. 9in. is required for the height of the crane hook above the floor level. When coupled to the 1200-kW generator, the overall length of the set is 35ft. 2in., with a width across the dynamo feet of 11ft. 6in.

Incidentally, we may recall the fact that this engine and generator were erected on the same foundation block that was previously used for a 400-kW set of slow speed continental design which it superseded.

Fig. 3 shows a cross section and a longitudinal section through one of the main cylinders, and illustrates several of the outstanding and patented features of the design. For convenience in casting and transport, the bedplate is made in two pieces, which are deeper at the centre than at the ends. The two halves are joined by fitting bolts, and, as the drawings show, a robust girder section is employed, which is strongly ribbed in the way of the main bearing support. At the centre of the engine there is a local sump to which all lubricating oil quickly gravitates. From this sump it flows to a settling tank fitted with strainers.

At the compressor end of the engine an annular facing is provided, and to it the air compressor casing is bolted, while there is an additional cast iron supporting stool bolted to a spigoted lower flange. Both the lower and upper faces of the bedplate are machined over their entire length, and the top facing carries the two monobloc three-cylinder crank casings. The main bearings have cast steel shells with a "Hoyt" metal lining, and are fitted for forced lubrication. Like the bedplate, the crank shaft is made in two portions. The method of securing the two halves by means of a deep cross key and fitting bolts in one of the crank webs is shown in Fig. 2. This drawing also illustrates the removable steel spiral gear wheel which drives the vertical shaft. A solid collar is formed on the crankshaft and the two halves of the wheel are drawn up into a recess in this collar by means of two slip rings pulled by fitted bolts on to a tapered length, thus binding the two halves of the wheel firmly on to the crank shaft. As shown in the drawing, thrust pads are fitted on the outside faces of the two centre bearing shells. Returning to the crank case, it may be noted that it is very stiffly constructed, so that the working stresses and reactions may be taken up without the use of fitted bolts. Access to the main bearings and the crank shaft is given by large-sized aluminium inspection doors on either side of the crank case, to which there is attached a circular sliding door of planished steel, which can be quickly removed and replaced. The top of the crank case is cored out to receive the cast iron cylinder casings, which carry faces for the platform supporting girders and a bracket for the cam shaft bearings and casing. There is a mechanically-operated lubricator for each of the cylinders, which are furnished with lubrication fittings at six different points.

Liner, Cylinder Head, and Piston.

Attention may be called to the special design of the cylinder liner at the top part, where the gas joint is made. Between the cylinder head, which consists of a slab of steel, and the hot gases of combustion, there is interposed a steel combustion plate, which is secured by studs to the cylinder head and is ribbed on its upper surface, thereby providing effective distribution of the cooling water over those surfaces which are directly in contact with the combustion temperatures. From the left-hand drawing on page 201, it will be seen that the gas joint is directly

above the supporting shoulder of the liner. Such an arrangement entirely eliminates bending stress, which it is very important to avoid when making a gas-tight joint to withstand a cylinder pressure of close upon 90 tons. The screwing-down load on the cylinder studs is approximately double that amount. The diagonal holes through which the cooling water passes up through the shoulder to the top side of the cast steel combustion plate may be referred to. Not only do they greatly assist cooling water circulation but the makers also claim that they impart a certain amount of flexibility to the upper part of the liner, thus enabling expansion to take place in any direction without the introduction of undue stress and liner deformation. There is a guide belt at the lower end of the liner which fits into the cylinder casing, a water-tight joint being made by a packed gland ring, accessible from the crank case. The main body of tensile aluminium alloy casting, all parts being secured by bolts.

The head of the piston is separate from the main body and skirt and has a deeply concave crown which is strongly supported by ribs. The upper part of the piston is secured to the lower by a series of tee-headed bolts and the lower part carries ported passages at its centre to which the cooling oil is led by means of a steel tube. The oil spreads radially from the centre to the sides of the piston head, and is returned through the outlet tube at the top of the piston space. The bearings of the cooling links, as shown in the right of our drawing, are of the double ball type, and a compression spring within thimble valves with spherical seats obviates leakage from the 30 lb. per square inch cooling oil system. Weldless steel tubes are employed. Attention may be called to the gudgeon pin bearings. The gudgeon pin, which is hollow and of an outer water jacket surrounding the inner gas passage, which is of stream-line design. The water enters at the lower end and travels at a high velocity to the top of the water casing, where it rises in a vertical discharge pipe and falls into the open water return tundish. With exhaust valves of this large diameter, namely, 7¼in., in the earlier engines, water-cooled valves were employed, but experience now gained with special heat-resisting metal, capable of withstanding temperatures up to 850 deg. Fah., has led to uncooled exhaust valves being used. Such a valve is simpler generally, in that it dispenses with passages and pipes, and is to be welcomed as an advance in design. From the drawings we reproduce, and also from the section of the engine shown below, it will be seen that the exhaust valve stem is guided by a central cast iron removable sleeve. This cast iron sleeve enables a larger clearance between the

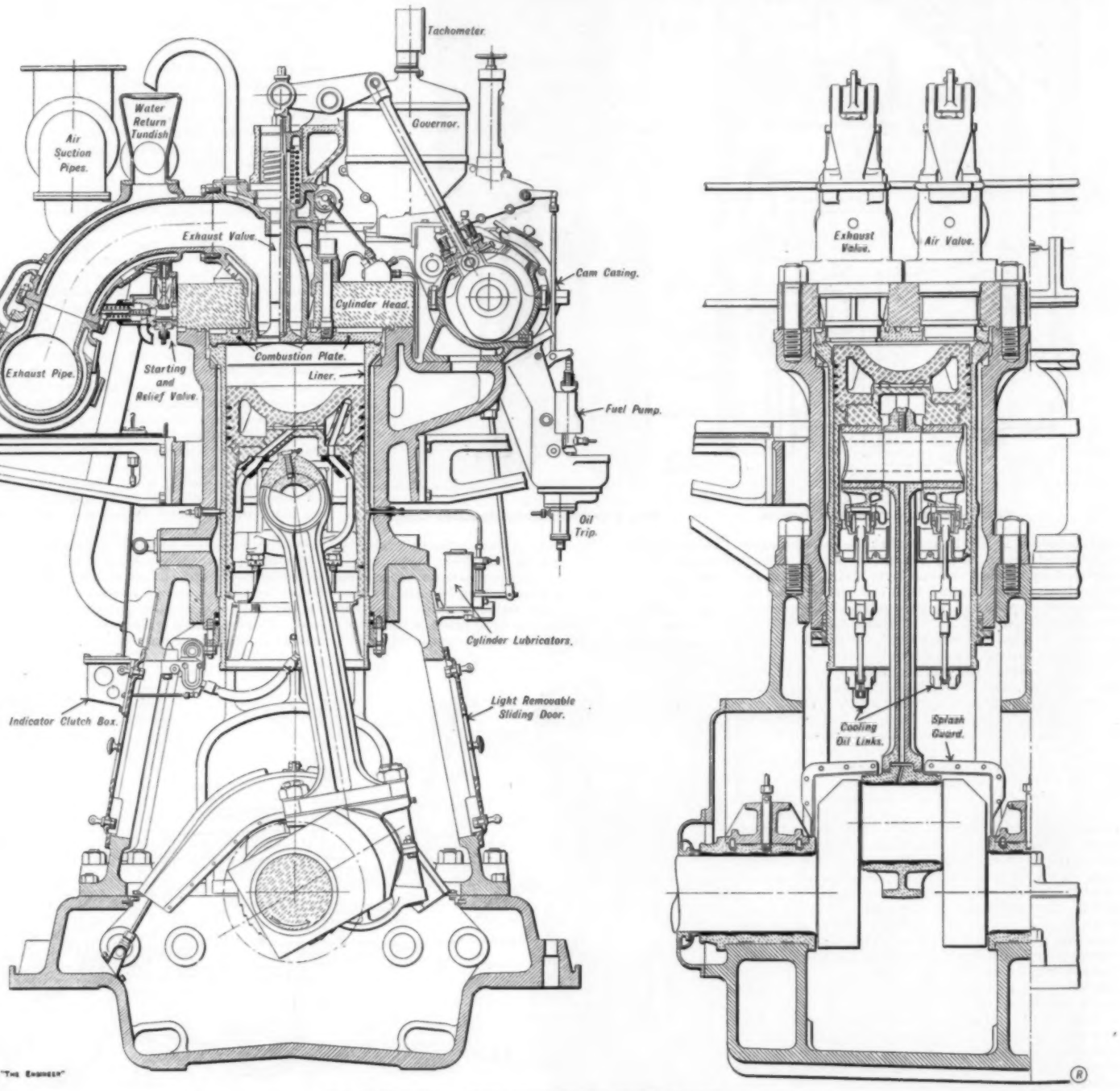


FIG. 3—VERTICAL SECTIONS THROUGH ONE CYLINDER

the liner is only ⅜in. in thickness, which should allow effective cooling to take place.

The liners are machined from solid steel forgings and are afterwards toughened by heat treatment. The wearing qualities of toughened steel have been shown by experiment effectively to withstand the lapping action of aluminium, which is very marked in cast iron liners. After a commercial test of a liner lasting about 4000 hours, the wear was shown to be negligible, and the makers are confident that the steel liners will continue in service a much longer time than would similar cast iron liners.

The piston design is not without novelty, and for that reason we give in Fig. 4, an enlarged section through the piston itself, while Fig. 5 shows the large and unbroken area of piston surface which is in contact with the steel liner, a factor of considerable importance with aluminium. A further important point in the design is the entire absence of screw threads in the high-fitted with end closing pieces, is shrunk into the top of the connecting-rod, and its bearings take the form of two solid bronze brasses which fit in a square recess on the piston and are held in position by steel caps. The top end bearing bolts are neatly recessed into the upper surface of the body of the piston. As shown the bearing bolts carry an extension stud to the lower end of which is fitted an aluminium splash guard and oil tray. Any oil escaping from the bearings, or oil returned within the piston by the lower scraper ring, is led away to the crank case by the drain pipe shown at the back of the left-hand cooling link.

VALVES AND VALVE-OPERATING GEAR.

In Fig. 3 the exhaust valve will be seen, while in Fig. 6 we reproduce drawings of the fuel valve, along with the operating gear, and the cam and hand-operated starting valves. It will be seen that the exhaust valve casing consists essentially valve stem and the sleeve to be given, which obviates valve sticking. Furthermore, the bottom of the cast iron sleeve is shrouded by a shield which deflects the exhaust gases and prevents them from entering the guide, and also assists in directing them in stream-line flow through the exhaust casing. It may be noted that double springs are used, so that in the case of one being fractured, the valve can still remain in operation until an opportunity is presented to remove the broken spring. In view of the high duty of this type of engine, which works at a normal mean indicated pressure of 120 lb. per square inch, very careful consideration was given, we understand, to the lower gas joint of the exhaust valve casing, where it enters the combustion plate. At this part the cooling water is induced to travel across the top of the combustion plate at a high velocity, and it therefore cools the lower edge of the exhaust valve casing and the valve to a large extent, and gives, so we are informed, a

working period of about 1500 hours before the valves require to be cleaned.

The drawing we reproduce in Fig. 6 shows the fuel valve and its operating mechanism. This valve is worked from the cam shaft through the medium of a bell crank lever acting on a horizontal push rod, which in turn makes contact with another small bell crank lever, the function of which is to lift the fuel valve needle. It will be seen that the fulcrum of the last-named lever is an excentric, which can be operated by a hand cut-out lever, bringing the fuel valve lever out of contact with the needle valve and also depressing the fuel by-pass valve. This operation immediately cuts off all fuel going to a particular cylinder, and, as the needle valve is not lifted, no injection air can enter. Such an equipment is very useful when an engine of the multi-cylinder type is running on light load, and it effects economies both in fuel consumption and air compressor work.

It may be further noted that the bell-crank lever on the cam shaft is also excentrically fulcrumed. The shaft carrying this lever is directly connected with the control levers for stopping and starting the engine. In the "stop" position of the engine the lever is thrown clear of the horizontal push rod and although the fuel cam toe continues to lift it, yet the clearance between the push rod and the end of the bell-crank lever prevents that motion from being transmitted to the fuel valve. A good feature in this arrangement of mechanism is that which enables the opening of the fuel valve to be retarded from 12 deg. to 15 deg. at the full speed of 300 r.p.m. to only 5 deg. before the top centre when the engine is being started at a slower speed of, say, about 100 r.p.m. This device is again useful for light-load running at long periods, for when the bell-crank lever is operating in the 5 deg. position less lift is given to the fuel valve and there is a smaller angle of opening on the cam.

Turning to the fuel valve itself, it will be seen that the fuel atomiser is of a simple type, and that no pulveriser washers are necessary. Good fuel penetration and wide distribution are obtained in the cylinder by the use of a cupped nozzle which is provided with five distributor holes. By means of a simple appliance these holes can be cleaned by withdrawing the fuel valve needle.

As shown in the drawing, adjustment of the fuel valve needle is made from the top, and the adjusting nut is easily accessible. All parts of the fuel valve operating mechanism are made of steel, and pins and rubbing surfaces are hardened to minimise wear. From Fig. 6 it will be seen that the fuel cam is accessible from the inspection door on the cam casing, and the whole cam gear running, as it does, in an oil spray bath is very clean in operation and requires no attention. Reference at this point may be made to the exhaust valve push rod, the roller end of which works in a steel crosshead housing which is formed on the cam shaft casing. Arrangements are made for automatically lubricating the crosshead, which is self-contained. A section through the push-rod crosshead is shown at the centre of Fig. 3.

Returning to the fuel valve, it will be noted that the lower valve body in which the needle seat is formed is made from a steel forging and that a tapered hole in the combustion plate prevents the cap nut holding the nozzle from falling into the cylinder should it at any time become loose. The lower fuel valve casing seating is water cooled, and the cooling water enters a similar recess around the exhaust valve casing. By this means a very thorough circulation takes place towards the centre of the combustion plate which promotes good cylinder head and valve cooling. The packing used in the fuel valve is, we are informed, of a special "Garlock" type, which has been employed to a considerable extent in marine practice and is said to possess long life and to give little wear on the needle valve surface. Another point to which attention has been given is the alignment of the needle valve. It will be seen that the valve is lifted from its extreme end and not from the point of contact with the lever. An advantage which the makers claim for this arrangement is that it reduces to a minimum any risk of a sticky valve being caused by misalignment.

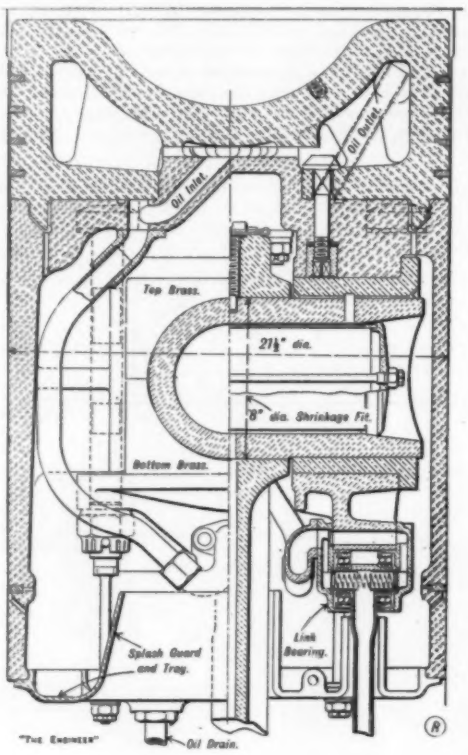


FIG. 4—SECTION THROUGH PISTON

FIG. 5—PISTON WITH COOLING LINKS

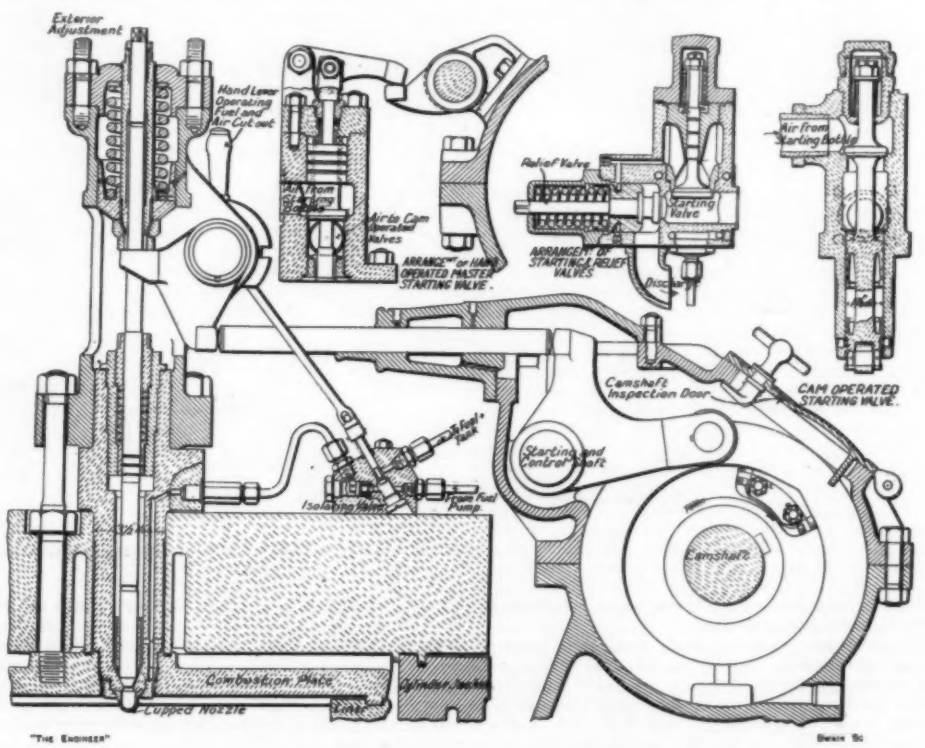


FIG. 6—FUEL VALVE ARRANGEMENT AND AIR STARTING VALVES

FUEL PUMPS AND GOVERNOR.

The fuel pumps, which form a very interesting, feature of the engine, are shown in Fig. 7, and in Figs. 8 and 9 the general arrangement of them with the governor and starting controls may be seen. The two fuel pump bracket castings are secured to the underside of the cam casing which supports the cam shaft bearings, and each of them carries a steel block which accommodates the plungers, suction and delivery valves, and the trip valves. Each plunger, it may be noted, is driven by its own excentric and it is so timed as to deliver fuel to the valves on the compression stroke of the cylinder it serves. The excentric straps are of the split type and are made in bronze, and the connecting link from each excentric is furnished with a spherical head working in a concave pad. By such an arrangement the heavy pressure on the down or delivery stroke of each plunger is amply provided for, and the plunger is self-aligning. It will also be observed from Fig. 7 that the top of each plunger is made spherical to ensure alignment between the top guide and the plunger barrel. The plungers are made of steel and are case-hardened and ground, and we understand that in future engines a glandless pump with each plunger working in a lapped cast iron guide will be fitted. A departure from conventional practice is that the suction valves are placed above and not below the delivery valves—see Fig. 7. The makers claim among the chief advantages for this arrangement easier facilities for the adjustment of suction valves which can be made while the engine is working, a more convenient and practical governor control, and greater accessibility and freedom from leakage.

The fuel in the pump bodies is kept at a constant level by means of a float valve chamber, so that the pumps are always flooded with fuel oil to a level above the seat of the suction valve, and priming is thereby avoided. Any air in the pump body simply rises through the suction valve and escapes past the guide. A useful provision which was demonstrated to us during the trial is a small spring catch fitted on each suction valve, so that when desired any pump line can be put out of action by depressing the suction valve into this catch with the finger, and thereby holding it from its seat. From Fig. 8 it will be observed that the rocking arms of the fuel pump are connected to the plungers through the medium of two ball races and are fulcrumed to a common cross shaft which is suspended from the governor by two drop rods. Thus any variation in the governor control alters the position of the cross shaft and varies the period of time during which the suction valves are off their seats. All springs in contact with fuel oil are made of a special spring steel which is nickel plated.

On the underside of the fuel pump body is a trip valve which serves the purpose of stopping the engine either by automatic cut-off, should the lubricating oil fail, or by the emergency overspeed governor should the engine exceed its normal designed speed by 10 per cent. This trip valve is also connected to the starting control levers for the purpose of cutting off fuel from those cylinders to which starting air is being delivered. The fuel from the trip valve is by-passed back to the suction chamber. The two delivery valves are seated in a special casing and are fitted immediately below the suction valves, as shown in Fig. 7. They are made of cast iron and nickelplated springs are also fitted. We have previously referred to the fact that the level of fuel oil in the pump is maintained constant by a float valve fitted in a small subsidiary chamber

alongside the fuel pump. This chamber is coupled to the main fuel supply tank. This tank is made up of two compartments and is fitted with an automatic calibrated tipping tank so that the exact amount of fuel supplied to the engine can be recorded by a counter. The supply of fuel to this tank is assured by a ball control feed valve from the storage tank.

AIR-STARTING SYSTEM AND ENGINE CONTROLS.

In Fig. 6 we show the cam-operated starting valve and hand-operated master valve. The starting air

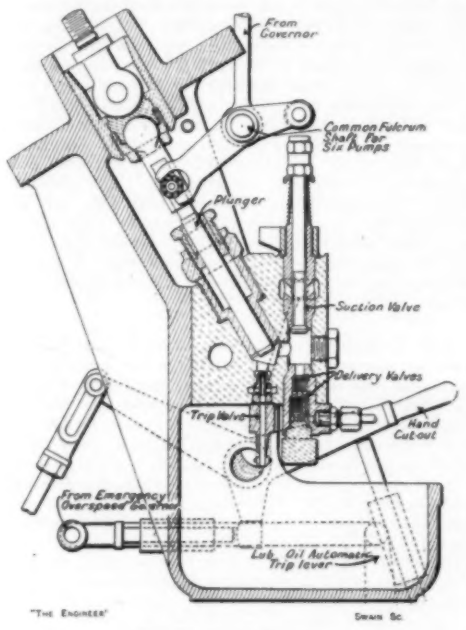


FIG. 7—FUEL PUMP

system is so arranged that when the starting air bottles are open to the engine, the attendant can take steps to see that a correct balance of pressure is obtained before proceeding to start the engine. In the six-cylinder engine with which we are dealing, the starting valves are fitted on three cylinders only. On pulling down one of the control levers shown on the centre panel on Fig. 9, the master starting valve shown on the upper part of Fig. 6 is lifted and air

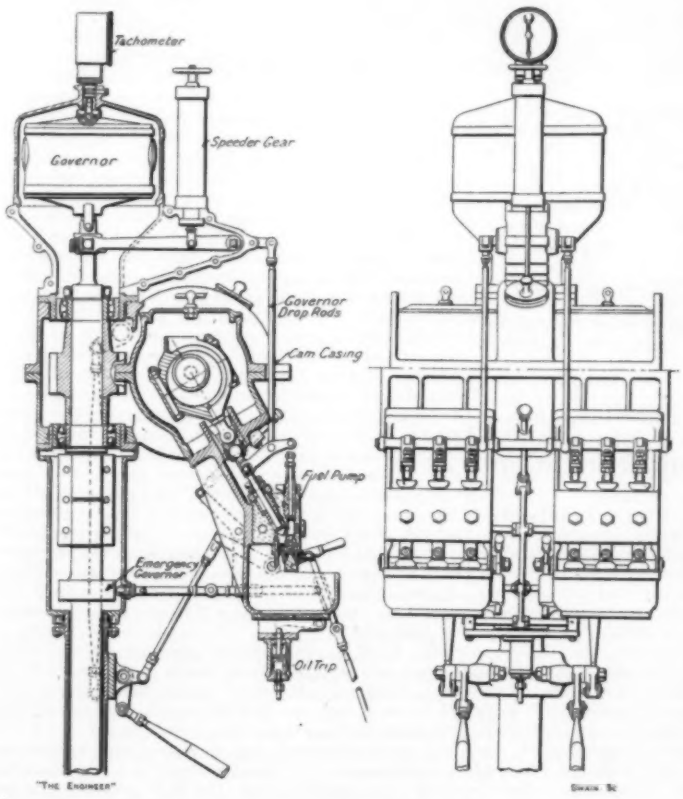


FIG. 8—GOVERNOR AND FUEL PUMP ARRANGEMENT

passes from the bottom to the upper side of the cam-operated valve shown on the same drawing. Whichever of the cylinders is to receive starting air the valve of that cylinder is lifted off its seat by its cam and allows the starting air to flow to the automatic starting valve shown in Fig. 6, and also at the back of the engine in the left-hand section on page 201. The high-pressure air thus opens this automatic valve and enters the cylinder, putting the engine in

motion. All high-pressure air boxes are made of steel, and those attached to the cylinder head are water cooled to prevent distortion of the valve seats. In each of the three automatic starting boxes on the cylinder heads is a relief valve, as shown in Fig. 6. The valves are set to blow at 750 lb. pressure per square inch, and mention may be made of the fact that they are larger in diameter than those generally fitted. Fig. 9 clearly shows the very neat arrange-

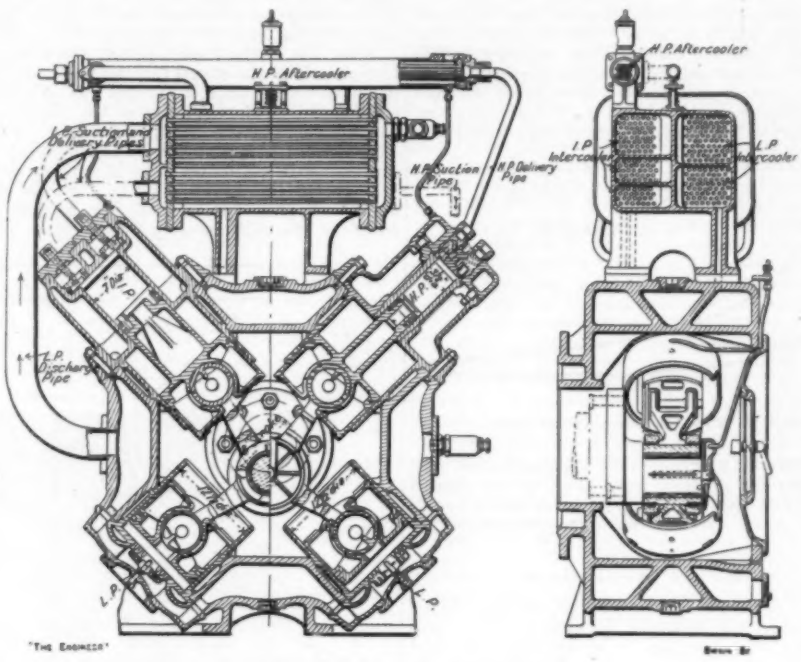


FIG. 10—REAVELL AIR COMPRESSOR

ment of the starting controls which are centralised in the front of the engine, and from which all operations connected with the engine and the air compressor are carried out. The fittings on the control board include exhaust gas pyrometers, visible piston cooling oil outlets and all the necessary pressure gauges for both the engine, starting bottles and the air compressor. The controls are so arranged that the engine can be

FIG. 9—ENGINE CONTROL BOARD

started by the attendant without moving from one position. The control board also has tell-tale lights from the switchboard, with a voltmeter and ammeter, and the arrangement is particularly neat, absence of pipework being a noteworthy feature.

The three levers operating the main engine controls are to be clearly seen in the centre of the control panel shown in Fig. 9. On pulling the lever shown to the left down past the lower notch, the master start-

ing air valve is opened and air is admitted to the cam-operated valves shown in Fig. 6. When the engine has made a few revolutions the lever to the right, which was at the lower position when starting, is raised to the top notch as shown, and fuel is admitted to the three cylinders not fitted with starting valves. As soon as the engine takes up on these three cylinders, the left-hand lever is raised into the position shown, which cuts off the starting air supply and puts the cylinder on fuel. When stopping the small centre lever is simply pulled down, thus cutting off the supply of fuel to all the cylinders by lifting the fuel pump trip valves.

AIR COMPRESSOR.

The air compressor which will be seen to the right-hand of the upper view on page 200 and a section through which is reproduced in Fig. 10, is of the Reavell Quadruplex type, being specially designed by Reavell and Co., Ltd., in conjunction with Fraser and Chalmers, for this particular type of engine. We have already referred to the strong annular connecting flange and the bedplate supporting bracket. The compressor crank chamber is, however, completely isolated from the engine, so that there is no possibility of lubricating oil from the main bearings

creeping along the surface of the crank shaft to the compressor crank pin. A feature of the design is the provision of inter-stage cooling, which is exterior to the compressor itself, and therefore easily accessible. Particular care was given to the balancing of the unit which was assisted by an advantageous arrangement of the delivery pressures in each of the three stages. As the low-pressure cylinders are very adequately cooled, it was possible to increase the terminal pressure in these cylinders, the efficiency of the set being thereby enhanced. Air is admitted to the low-pressure cylinder through the Reavell type of ported gudgeon pins, which do away with the necessity for spring-loaded suction valves. The delivery valves of the low-pressure and intermediate-pressure stages are of the plate type, thimble valves being retained for the high-pressure delivery valves. The care given to the design of this special machine has resulted in a

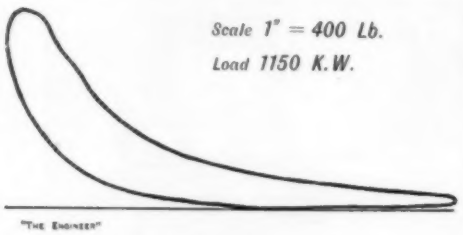


FIG. 11—TYPICAL INDICATOR CARD

highly satisfactory performance being attained, and we are informed by the makers that the test figures show that this type of compressor gives better results than any other type of three-stage compressor yet produced.

TRIALS AND TEST RESULTS.

We were invited to attend some of the bench trials of the engine while it was at the makers' works, and also to see it under load in commission. It was particularly interesting to verify for ourselves the working of the automatic emergency control, which shuts down the engine in case of any failure, either in the forced lubrication system or in the supply of cooling oil delivered to the main piston. The lubricating oil pressure was made to fail and the engine was immediately brought to a standstill, and it could not be started again until the pressure had again been established in the oil system. The engine was remarkably quiet and free from vibration at all loads,

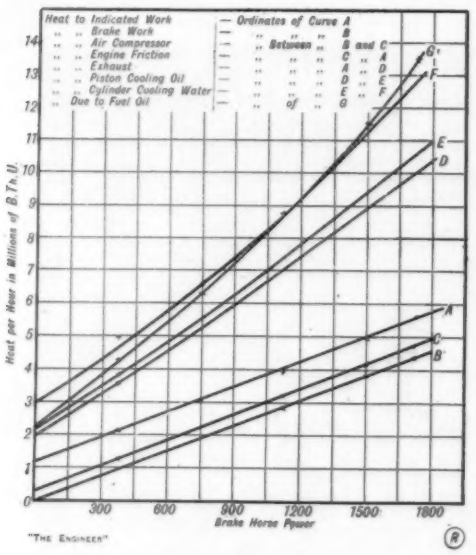


FIG. 12—HEAT DISTRIBUTION CURVES

owing, we are informed, to the great care taken in the analysis of the engine and the dynamo from the point of view of torsional vibration and critical speed. It may be placed on record that there is no outboard bearing between the engine fly-wheel and the 1200-kW 180 to 220-volt, G.E.C.-Witton generator, and with this arrangement the calculated critical speed of the shaft fly-wheel and dynamo was 355 r.p.m. Although it is designed to operate at 300 r.p.m. and an emergency governor cuts out the fuel at a maximum speed of 330 r.p.m., the engine was tested at 320 r.p.m. and vibration was entirely absent. It may be noted that when starting or stopping the engine, it is never called upon to pass through a critical speed. In Fig. 11 we show a typical indicator diagram, reproduced full size, which was taken at Short's Gardens power station when the engine was working on an electrical load of 1150 kW. From the shape of the diagram, it may be gathered that combustion takes place gradually from the ignition point until a peak is reached at about 30 deg. beyond top dead centre. This being so, maximum pressure is exerted on the piston when it is at its most useful position. The compression pressure is about 470 lb. per square inch and the combustion pressure about 570 lb. per square inch. When the indicator diagrams were being taken, we had occasion to note the convenient arrangement whereby the indicator gear motion is put in and out of action by a small clutch arranged at the back of the engine. By turning a small handle on the clutch box, the mechanism is disengaged, while the cord hook is attached and the clutch gear is only in operation when the diagrams are actually being taken The drive for the indicator is attached to the piston cooling link mechanism and particular care was taken in its arrangement to obtain an absolutely true reproduction of the reciprocating motion of the main piston.

After one of the trials a piston was drawn for our inspection and the actual time required from shutting down the engine until the piston was on the floor was only 32 min. Examination of the piston and liner surfaces showed that they were in good condition with a hard glossy surface. The gudgeon pin was also removed and found to be in entirely good order. In Figs. 12 and 13 we show trial results plotted in various ways, so as to make the records complete from the thermodynamic point of view. In Fig. 12

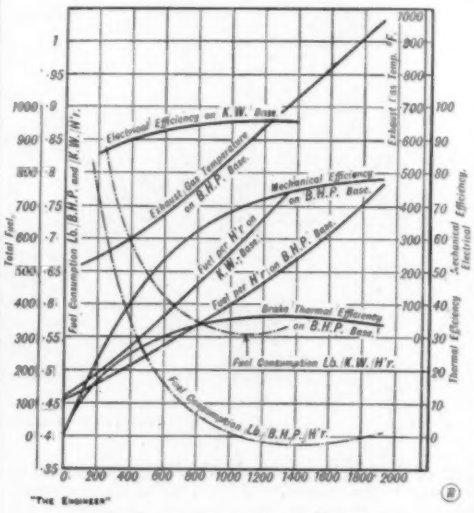

Electrical Efficiency on K.W. Base
Exhaust Gas Temperature on B.H.P. Base
Mechanical Efficiency on B.H.P. Base
Fuel per H'r on K.W. Base
Fuel per H'r on B.H.P. Base
Brake Thermal Efficiency on B.H.P. Base
Fuel Consumption Lb./K.W./H'r.
Fuel Consumption Lb./B.H.P./H'r.
Total Fuel, Fuel Consumption Lb./B.H.P. and/K.W./H'r.
Exhaust Gas Temp. °F.
Mechanical Efficiency. Electrical Efficiency. Thermal Efficiency
"The Engineer"

FIG. 13—PLOTTED TRIAL RESULTS

the distribution of the heat and the various losses are clearly shown, and, at full load, the heat balance may be given as follows:—Heat converted into indicated work, 45·5 per cent.; heat rejected to the cooling water, 17·6 per cent.; heat rejected to the piston cooling oil, 4·1 per cent.; heat rejected to exhaust, 32·8 per cent.; total, 100 per cent. The curves which are reproduced in Fig. 13 show fuel consumption curves per B.H.P. hour and kW hour, with total fuel curves both on a B.H.P. and kW basis. The brake thermal and mechanical efficiencies of the engine are also shown, while the electrical efficiency of the generator is given on a kW basis. A useful feature of the curves is the inclusion of the exhaust gas temperatures plotted on a B.H.P. basis for the complete range of engine power. This curve is of especial interest, as it shows the range of temperature to which a high-duty engine of this large output is subjected.

In conclusion, we would express our thanks to builders and designers of the engine, who have co-operated with us in the preparation of this article, and have generously placed at our disposal complete drawings and results.

Institution of Mechanical Engineers.

THE report of the Council for the year 1927, submitted at the eighty-first annual general meeting of the Institution of Mechanical Engineers, held in London on Friday evening of last week, February 17th, shows that there was a net gain of 139 in the membership, and that the total number of members at the end of the year was 10,256. The financial statement shows that the revenue for the year amounted to £31,925, and that the total expenditure reached £31,214. Dealing with the work of the Research Committees the report states that work for the Alloys of Iron Research Committee, a body in which several learned societies are interested, was continued during the year at the National Physical Laboratory, under Dr. Walter Rosenhain. It has consisted chiefly of investigations of the alloys of iron and manganese, chromium and silicon, and has involved the preparation of the alloying element in a high state of purity and the evolution of special refractories not reactive to the molten alloys. The Cutting Tools Research Committee has presented to the Council a report on "Machinability," by Mr. E. G. Herbert. On its behalf Professor Dempster Smith and Sir Thomas E. Stanton are conducting investigations respectively into the cutting of brass with high-speed and carbon tools, and into the speed-effect characteristic of materials having a high ratio of yield stress to ultimate stress. The Hardness Tests Research Committee has presented a report prepared at the National Physical Laboratory, by Mr. G. A. Hankins, entitled "A Synopsis of the Present State of Knowledge of the Hardness and Abrasion Testing of Metals with Special Reference to the Work Done During the Period 1917 to 1927." The Steam Nozzles Research Committee has presented its fifth report. This report was discussed at a meeting of the Institution held in London on January 20th, and was summarised in our issue of January 27th. A third report from the Wire Ropes Research Committee has been prepared for presentation early in 1928. At Woolwich Polytechnic Dr. W. A. Scoble has finished the tests on all the 1in. circumference ropes of 100/110 tons per square inch tenacity, and a large machine for testing ropes 2in. in circumference two at a time has been completed and put into operation. A sub-committee under Professor W. E. Dalby has been appointed, and grants have been made in connection with researches conducted in University laboratories. The subjects being investigated under these conditions are the boosting of a high-speed petrol engine; the airless injection of liquid fuels into the cylinders of oil engines; and the distortion of steel on hardening. These investigations, it is noted, are all in their preliminary stages.

The Council's report was carried unanimously without discussion, and following the presentation of prizes, the retiring President, Sir Henry Fowler, vacated the chair. The new President, Mr. Richard Allen, was unable by reason of illness to be present, and the chair was accordingly taken by the senior Vice-president, Mr. Daniel Adamson. A very cordial vote of thanks to Sir Henry Fowler for his unremitting and valuable work as President during the past year was moved by Dr. H. S. Hele Shaw, and was seconded by Sir John Dewrance, and carried enthusiastically. Thereafter Major W. Gregson was called upon to present his paper on "Waste Heat Recovery." This paper, partly in summary and partly in full, is reprinted elsewhere in this issue.

WASTE HEAT RECOVERY.

Mr. R. C. Macdonald, chief mechanical engineer to the South Metropolitan Gas Company, was called upon to open the discussion on Major Gregson's paper. He said that the first waste heat boiler that came under his notice was one attached to a strip heating furnace in a tube works. The waste gases were passed along external side flues at the bottom of the boiler, and were returned through an internal flue about 5ft. in diameter placed excentrically to the cylindrical boiler shell. The boiler was most inefficient, but it supplied sufficient steam for all the hydraulic power required in the works. The second waste heat boiler which came under his notice was one of the portable locomotive type, and was attached to a gas engine. It gave very satisfactory results. Dealing with the use of surplus gas in steel works, he remarked that he knew of a Middlesbrough steel works at which the waste gases, after being used for steam-raising purposes, were passed under salt-evaporating pans. Discussing the question of fire-tube *versus* water-tube boilers for waste heat utilisation, he said that in his opinion it did not matter much which type was used so long as the tubes were kept clean. Waste gases were usually heavily charged with dust, and that dust became deposited in the tubes. A fire-tube boiler had many advantages if the gases were dirty, but if they were clean water-tube boilers were equally satisfactory. He desired Major Gregson to tell him which type of water-softening apparatus he found best suited to the hard London water, and to state whether in waste-heat boilers working intermittently, any difficulty was experienced with wasting on the fire side consequent upon the formation and action of SO_3. The author seemed to imply that all the steam required in a gasworks could be obtained by the utilisation of waste heat, and showed that at an inlet temperature of 800 deg. Cent., and with 100 per cent. of excess air, something over 5 lb. of steam per pound of producer coke was to be expected. He, the speaker, thought Major Gregson was optimistic in that connection, and that he did not make sufficient allowance for intermittency of working. From 3 lb. to 4 lb. of steam was about the correct figure realised in practice.

Mr. F. H. Livens showed some lantern slides illustrating the application of waste heat boilers to gas and oil engines. He could, he said, confirm that about 2¼ lb. of steam per B.H.P. could be obtained from the heat in the exhaust gases. In some of his tests he had obtained a higher yield, but that figure was a fair average value. He illustrated by a slide an installation consisting of two 150 H.P. engines and one 200 H.P. engine fitted with exhaust gas water heaters and stated that in that installation, when the engines were working at 60 to 70 per cent. of their full load and with their exhausts at a temperature of 650 deg. Fah. 1070 B.Th.U.'s were recovered per horse-power, and the water was raised about 84 deg. It was essential to have sufficient storage capacity in such a plant for it might frequently happen that the demand for hot water was least when the engine load was greatest and *vice versâ*. It was very difficult, he concluded, to obtain consistent test results from waste heat recovery plant, because of the number of varying factors

and because a very little amount of deposit in the tubes was sufficient to upset the results.

Mr. J. Reber remarked that the author in his calculations had relied upon Mallard and Le Chatelier's figures for his specific heats. Those figures were, however, now known to be too high. He suggested that it would be of very great advantage if international standardisation could be effected in the units and data used in the compilation of heat balances.

Mr. W. H. Patchell said that ten years ago he had been responsible for the installation at Chelmsford of a 500 horse-power producer gas engine plant fitted with waste heat boilers. Those boilers were still at work. On test the three boilers with the engines at full load gave 2·15 lb., 2·49 lb., and 1·92 lb. of steam per B.H.P. hour. A similar boiler on a Diesel engine gave 2·07 lb. The boilers had now run for from 28,000 to 35,000 hours without repairs or renewals other than the replacement of the tubes. The tubes were of steel.

Mr. Thomas Clarkson argued that steel works and gasworks were on an entirely different footing from internal combustion oil engines as regarded waste heat recovery. In oil engines the exhaust gases were much lower in temperature; in fact, the highest oil engine temperature was not so high as the lowest encountered in steel or gasworks. He joined issue with the author on the merits of the fire-tube boiler and referred in particular to the Clarkson thimble-tube type of boiler. That design of boiler, he said, closely indeed with the truth. Given the volume and temperature of the gas, the law provided a very close figure for the performance of a waste heat boiler at any temperature.

Mr. Daniel Adamson said that all over the world commercial results of the greatest value were being obtained from waste heat boilers. In this country it was estimated that about 250,000 tons of coal were being saved annually by the use of waste heat boilers. In the United States one boiler maker alone claimed to have supplied waste heat boilers which were saving 200,000 tons of coal a year, while in Germany 100 million kWh were being obtained from waste heat recovery. It was particularly desirable that steel works should grasp what was open to them in the way of utilising their waste heat.

Major Gregson, replying to Mr. Macdonald, said that he did not agree with him regarding the general usefulness of fire-tube boilers. For softening London water there were half-a-dozen firms which would supply suitable apparatus for the purpose. He maintained that there were many gasworks in this country which were running entirely on their waste heat boilers in spite of their fluctuating load. He also adhered to his figure of 5 lb. of steam per pound of producer coke in vertical retorts. Such retorts, he remarked, differed entirely in their heat balances from horizontal retorts. Dealing with Mr. Livens' remarks, he said that with modern instruments there was no difficulty at any point in obtaining trust-

CLARKSON THIMBLE-TUBE WASTE HEAT BOILERS FOR SUBMARINES

could generate steam as well as produce hot water, and it could be run without water as a silencer when neither steam nor hot water was required. Mr. Clarkson showed several lantern slides illustrating the application of waste heat boilers in motor ships, in submarines and on motor-driven trains. We illustrate herewith the Clarkson thimble-tube boilers fitted in the two "O" class Australian submarines recently constructed in this country.

Mr. H. A. D. Acland, of the Still Engine Company, said that he was glad to observe the author's attempt to lay the bugbear of acid corrosion. So long as the temperature did not drop below the dew depositing point there was no danger of the formation of sulphuric acid in waste heat plant. Even in a feed heater the formation of acid was not likely to cause much trouble. Cast iron was practically impervious to acids and in any event was cheap to replace. Even a steel feed heater showed great powers of resistance to the attacks of acid. A steel feed heater made by his firm fifteen years ago was still in use and showed no signs to-day of acid corrosion. The profit to be gained by the use of a water heater on oil engines was not to be ignored even in the case of the low-temperature gases from a two-stroke engine. The author, he noted, seemed slightly to have exaggerated the ratio of excess air in a two-stroke engine. It could not in general be taken at 300 per cent., but was usually of the order of 200 per cent.

Mr. A. E. L. Chorlton said that he would have liked to have heard more about the construction of waste heat boilers as distinct from their performance. It was surprising to find how small the boilers were required to be. The original waste heat boilers were too large and the flow through them was too slow, and as a result corrosion was set up.

Mr. C. P. Taylor said that little information seemed to be available from which the performance of waste heat boilers might be deduced. Some years ago, however, Mr. Lawford H. Fry, as the result of certain investigations which he had carried out, set up a law for the flow of heat through gas tubes. He, Mr. Taylor, had tested that law on a waste heat boiler and had found that it gave results agreeing very worthy test figures from a waste heat installation. None of the figures given in the paper had been assumed; all were based on what had been attained in practice. He agreed with Mr. Reber that the Mallard and Le Chatelier specific heat figures were not correct at high temperatures, but at lower temperatures they could be accepted as fairly accurate. He also agreed with Mr. Reber regarding the desirability of standardising the basic figures used in engineering calculations. Dealing with Mr. Clarkson's thimble-tube boiler, he said that the design undoubtedly promoted turbulence in the gases, but it did so at the expense of creating high back pressure. Mr. Clarkson interposed to contradict this view, and said that the thimble-tube boiler produced no back pressure. Major Gregson replied by maintaining that the boiler replaced the silencer and would only admit that it produced no additional back pressure. He characterised as appalling the practice of running the boiler dry simply as a silencer. What would happen, for example, if, when the boiler was being run dry, cold water was suddenly turned in it? Mr. Clarkson, again interposing, stated that just such an experiment had been carried out during an Admiralty test and that nothing had happened. To Mr. Chorlton's remarks Major Gregson replied that his paper was on waste heat recovery and not on the design of waste heat boilers. He had to choose between these two subjects, and his choice fell on the more general one. Concluding, he emphasised a remark made in the opening paragraphs of his paper to the effect that it was very difficult to get people to realise that since the war everything economically had changed. Certain economic factors had come to stay, and it was useless to wait for the time when the cost of labour and materials would return to their pre-war level.

NORTH-WESTERN BRANCH.

Major Gregson's paper was submitted to a meeting of the North-Western Branch of the Institution held on Thursday, February 16th, and resulted in a lengthy discussion. The Chairman, Professor Watkinson, in opening it, said there were two main ways in which manufacturing might be carried out under the best conditions. One was by making the cycle of operations self-contained without any by-products, and there were a few industries in which that could be done. The other way was to utilise by-products, one of which was waste heat. Mr. Daniel Adamson called attention to several minor points in the paper which he considered could have been dealt with better. One was that there were no deductions for fan power; another was that the author had given his temperatures in Centigrade only, whereas the Fahrenheit scale was more generally used by engineers, especially in connection with B.Th.U.'s. He said that in the paper the author had dealt more gently with the water-tube boiler than he had done in his *résumé* that evening. The water-tube boiler was quite unsuitable for the higher gas velocities which were desirable in recovering waste heat from a medium which had not got much heat to part with. He had read about a boilermaker in the United States who claimed to be saving over 200,000 tons of coal per year, presumably with water-tube boilers. He could have done 10 per cent. better with fire-tube boilers. The recovery of waste heat was not at all a doubtful question, as the paper showed, and a perusal of the paper ought to convince steel works managers of the direct advantages to be derived therefrom.

Dr. Morley, referring to Mr. Adamson's remark on fan power in connection with such plants as were described in the paper, said that there were other appliances of a somewhat different nature aiming at the same end and using somewhat similar means. High-speed gas flow was a principle which could be adopted with great success. While fan power was essential in any scheme using gases flowing at high speed, the power absorbed need not be excessive. He had one in mind, where the expenditure of power on the fans for getting very high gas speeds was about 2 per cent. of the output of the whole appliance. Referring to the recovery of heat from the exhaust of an engine fired with blast-furnace gas, Dr. Morley thought the 100 per cent. on which the author's calculation was based was somewhat high. For that reason the amount of heat available in the gas was somewhat higher than was likely to be the case in actual practice. Hence the steam per brake horse-power hour of the engine referred to on page 7, namely, 2·2 lb., was rather high. The figures given for exhaust heat from oil engines was moderate.

Mr. Tomlinson said that in the early days of continuous vertical retorts gasworks had, instead of recovering waste heat, transmitted it to the air for combustion. When it was required to pass steam through the charge and make water gas in the same retort, it had been found that the steam itself performed the office of cooling the coke, and at the same time it recovered the heat and passed it up inside the charge in a highly efficient manner. He gave some figures for the new gasworks at Stoke, which showed that the power for the mechanical operation of the plant had been produced at well under ½d. a kilowatt-hour. It might be of interest to know that on that plant over 10,000 lb. of steam per hour had been raised. Of it some 3330 lb. were required for the gas-making process, and some 3100 lb. were required for power generation, leaving some 3500 lb. for other purposes in the works. Another rather striking fact was that, on a good many of those plants, the saving in fuel alone enabled the boilers to be paid for in some two years' working.

Colonel Carr said that he had had experience in the recovery of waste heat in gasworks processes, and could endorse the figures which had been put forward by Major Gregson in the paper. Major Gregson had rather erred on the safe side, in that he gave recovery in horizontal retort settings. The highest recovery was 3·55 lb., and the lowest was 2·98 lb. of steam per pound of fuel used in the producers. Was the fuel used in the producers given as carbon, or was it coke as charged with ash content, or was it given as ash carbon? He knew that with coke as charged as high a figure as 4·2 lb. of steam per pound of coal had been achieved with horizontal retorts. The coke in that instance was fed hot to the producers, and therefore there was no allowance for moisture, as there would be if the coke were fed after being quenched. In retort settings the great trouble was infiltration of air. It was absolutely essential in waste heat recovery to keep down excess air. In retort settings where there were regenerating flues, and access to those flues was necessary for cleaning purposes, the difficulties were enhanced. The smallest amount of air infiltration would bring down efficiencies enormously on account of the excess air content.

Mr. Orton said that the figures which Major Gregson had given in the section of the paper dealing with oil engines were strictly moderate, as had already been shown by Dr. Morley, and agreed very closely with practice, *i.e.*, the amount of heat in the exhaust gases from engines and the calculations of the saving obtained seemed to be quite moderate and could actually be obtained.

Mr. Fred Jones said that there seemed to be rather a mistaken notion regarding regeneration in furnaces. He thought that regenerators were put in chiefly to give a high furnace temperature. Temperature conditions in a furnace were really more important than thermal efficiency. When there was the best

possible regeneration there was still ample heat left in the waste gases for utilisation in a waste heat boiler. He had taken some results from six different furnaces with varying coal consumptions. The actual consumptions per ton of steel had ranged from 3½ cwt. to 7 cwt., and he had estimated the value of the steam in terms of coal saved by the waste heat boiler and subtracted that figure from the gross coal consumption. It had been surprising to find that the net coal consumption had come out at from 3·2 cwt. to 3·6 cwt. per ton of steel. Taking Major Gregson's figure of 2000 lb. per ton of steel and adding to that 500 lb. raised from the reheating furnaces and soaking pits, if that steam were used in a modern turbo-generator using 16·5 lb. of steam per kWh, 150 kWh of steam would be generated per ton of steel.

Mr. George Adamson said that Major Gregson had mentioned one thing which he had not seen before. It was the installation of waste heat boilers for low-pressure work at the back of high-pressure boilers in place of air heaters and economisers. He had always understood that air heating had a double effect: it not only recovered some of the heat in the waste gases, but it also improved the combustion conditions in the boiler furnace and so improved the efficiency. He would like to ask Major Gregson if, in addition to his waste heat boiler at the back, he would put on an air heater, and, if so, whether he would put it in front or at the back of the low-pressure boiler. He could endorse what Major Gregson had said about the usefulness of the subject. One firm he knew was saving 65,000 tons of coal a year by means of waste heat boilers. That particular firm about five years ago had been shut down because it had not been able to compete with the Continent. Now it was beating the Continent in price.

Mr. E. Spencer Wilkinson said that Major Gregson, in the course of his remarks, had mentioned the two-stage boiler proposition, comprising two Babcock and Wilcox boilers, followed by an ordinary fire-tube boiler. He stated that the efficiency of that installation was higher than that obtainable with the ordinary boiler, economiser, and air heater. Perhaps he would give them the definite efficiencies in each case, the method of firing, and the final outlet temperatures of the gases as they were rejected to the chimney.

Major Gregson, replying to the discussion, said, referring to Mr. Daniel Adamson's remarks, that the fan powers were worked out on all the tests given in the paper, and reduced to actual steam equivalents in each case. He fully realised the difficulties due to using a combination of the Centigrade and Fahrenheit scales, but as long as metallurgical and gas engineers thought of gas in the Centigrade scale and mechanical engineers of steam in the Fahrenheit scale, he believed that his compromise was the most workable under present circumstances. Referring to the heat losses between regenerator outlets and boiler inlets, the only solution was an air-tight steel system of flues, as shown on some of the lantern slides. He agreed with Dr. Morley that there were methods of heat recovery other than by steam raising, but the system of combined air and feed water heating referred to by Dr. Morley was more applicable to boiler practice than to furnace waste gases. He had found that 100 per cent. excess air was a fair figure for large blast-furnace gas engines operating at full load, his tests ranging over a considerable number of makes, all operating at rated efficiency. With a lower excess air content, combustion in the cylinders suffered. He would remind Dr. Morley, in comparing the gas engine recovery results with oil engine practice, that the Diesel cycle was essentially more efficient than the explosion cycle, and that fact, coupled with the lower-grade gases at the exhaust manifolds, accounted for the lower recovery figure. Mr. George Adamson had referred to two-stage steam generation, and he regretted that in his summary of the paper he had not made it clear that air heaters were to be used when necessary, *e.g.*, when firing pulverised fuel, the performance of the low-pressure boiler being regulated to suit individual designs. Even without air heaters the temperature of the gases leaving the low-pressure boiler would be lower than those of the gases leaving an economiser under similar conditions, as the water in the latter was worked up to full boiler temperature and not the temperature corresponding to the low-pressure steam system. This answered Mr. Wilkinson's query also.

The New Road Bridge Between Newcastle and Gateshead.

In our issue of December 30th last we gave a description of the new road bridge, which is being built over the Tyne between Newcastle and Gateshead. Included in the article were reproductions of photographs taken of the structure a few weeks previously. Since then, rapid progress has been made with the erection of the steel work of the arch portion of the bridge, as will be realised from the accompanying engraving, which has been reproduced from a photograph taken a short time ago. In fact, the arch is seen to be within measurable distance of completion, and good progress has also been made with the construction of the platform that will carry the roadway.

By the aid of the diagrams showing stages in the erection of the bridge, which were also given with the article mentioned above, our readers will be able to realise the proportion of the work that has been finished and how comparatively little remains to be done, so far as the main erection is concerned.

THE NEWCASTLE-GATESHEAD NEW ROAD BRIDGE

The Birmingham Carbonisation Conference.

No. I.

The Carbonisation Conference which has been held in Birmingham this week, and of which we now give some account of the early portion, served to emphasise the magnitude of the problems involved and the absolute necessity for co-operative action in any discussion of them. This Conference was the fourth of a series organised by the Joint Fuel Committee, a body hitherto composed of representatives of the Institution of Gas Engineers, the Society of Chemical Industry and the Coke Oven Managers' Association. Now, however, the Institute of Fuel—which, by the way, is gradually and consistently adding to its membership in a very satisfactory manner—has joined the Joint Fuel Committee, and this fourth Conference was the first in which it has taken part. The programme arranged for a full-day meeting on Tuesday, February 21st, half-days on the following two days, and a full day on the final day of the Conference. On Wednesday, February 22nd, there was a luncheon at the British Industries Fair, by invitation of the Fair authorities.

A feature of the Conference was the fact that all the papers presented for discussion had already been presented to one or other of the organisations concerned with fuel problems, and the scope of the Conference may be gauged from the fact that, although there were no less than 400 letters of regret, there were 300 acceptances of invitations to attend. Of course, this latter number was not present throughout, owing to the interest being spread over such a wide area, and it was as well that it was not, for had it been the lecture room at the Birmingham and Midland Institute would have fallen woefully short of the requirements. As a matter of fact, the first day's proceedings did not follow out the programme, because, after the brief introduction of six papers and the discussion upon them, it was found that there was not sufficient possibility of further discussion to warrant the holding of the afternoon meeting as had been arranged, and those attending the Conference were able to pay a little more attention to the Fair at Castle Bromwich than they would otherwise have been able to do.

The Conference on the first day was opened by Sir Richard Threlfall, F.R.S., Chairman of the Fuel Research Board, who recalled that thirty years ago, when he first became interested in fuel, he could not find anybody who was inclined to discuss the matter with him. People in those days were only concerned with the price, but nowadays there was a large body of people taking an interest in the scientific aspect of the problems concerned. In the early days, continued Sir Richard, he had had the opportunity of spending a month in the works of the late Thomas Parker when low-temperature carbonisation was being investigated, and he reiterated what he had said on several previous occasions, that, had Mr. Parker's efforts been carried out in a gasworks, there would have been a reasonable prospect of success. Sir Richard went on to comment upon the versatility of James Watt in this connection, because, although best known as the improver of the steam engine, he also took a very keen interest in smoke prevention, as was to be gathered from a perusal of the collection of his letters. This work of Watt's, however, was a century and a-quarter ago, and it was amazing now to find that extended experimental work was still required upon fuel problems.

Professor Arthur Smithells, F.R.S., Chairman of the Joint Fuel Committee, spoke of the manner in which the Birmingham Corporation Gas Department had always been in the forefront of carbonisation progress, and said that there existed in Birmingham to-day examples of carbonisation plant and processes which could not be surpassed in any part of the country. After referring to the fact that Sir Richard Threlfall's work upon fuel problems really began in Australia—where he acted as Chairman of the Royal Commission there which had to consider the loading and carrying of coal at sea—Professor Smithells said that there would always be scope for research into fuel problems, and always be scope for conference and discussion with regard to them. One thing he hoped for from the present Conference was that it would afford some guidance to the public as to how far fuel problems had been solved. At the present time he felt it was a source of anxiety and alarm that the public should be so much at the mercy of those who made explicit and definite statements, with great confidence and great publicity, that some of the most difficult questions connected with fuel had been solved. Such a Conference as this, should through the Press, give the public some clear idea as to how far the various problems had actually been solved, so that they would be put on guard against putting their belief and their money into enterprises concerning which claims were put forth that were not, at the present stage, fully justified.

Dr. G. C. Clayton (Society of Chemical Industry), who presided at the Conference on the first day, referred to the objects of the Joint Fuel Committee. They were to spread accurate information with regard to the matters involved. In remarking upon the fact that the papers put forward for discussion at that meeting concerned principally the gas industry, he said that that industry had always been in a somewhat exceptional position in that the freest exchange of opinions took place between the different authorities and technical workers, and it was largely on that account that it had developed along sound, if somewhat cautious, lines to its present magnitude. There was little doubt that progress would be stimulated similarly by freer interchange of data and experience in other industries, because, although gratifying progress was being made, much more still remained to be done. In certain other sections of the fuel industries there was still a certain hesitation evinced by firms in putting the whole of their cards on the table. That fear was gradually being broken down, however, and he expressed the hope that that Conference would provide a stimulus to discussions. Finally, Dr. Clayton spoke of the time usually taken between the completion of a research and its adoption in industry, and pleaded for every effort to be made to curtail the waiting period so often experienced.

The following papers were then submitted:—"The General Scope of the Gas Industry," by Mr. W. J. A. Butterfield; "Some Phases of Modern Practice in Gas Manufacture," by Mr. Thomas Hardie; "Presidential Address to the Southern Association of Gas Engineers and Managers, 1927," by Mr. Thomas Hardie; "Continuous Vertical Retorts," by Messrs. Michael Barash and T. Campbell Finlayson; "Vertical Intermittent Chamber Ovens for Gas Manufacture," by Mr. N. J. Bowater; and "Intermittent Vertical Chambers," by Mr. R. H. Bruton. On Wednesday, February 22nd, the following papers were read:—"The General Scope of the Coke Oven Industry," by Messrs. C. P. Finn and R. Ray; "Modern Coke Oven Practice," by Messrs. G. J. Greenfield and G. H. Harrison; and "Coke Research and the Steel Industry," by Mr. E. C. Evans. A short review of the outstanding points arising on these and other papers will be given in our next issue.

(To be continued.)

Arrangements are being made for the manufacture of aero engines, by the Armstrong-Siddeley company at Ottawa, Ontario.

The British Industries Fair at Birmingham.

THERE are two outstanding features about the British Industries Fair, which opened at Birmingham on Monday last, and will close on March 2nd. They are the greatly increased accommodation available for the exhibits and the enthusiasm of the exhibitors. The pessimism which was rather evident a few years ago seems to have disappeared, and all are looking forward to a good return for their outlay on the Fair. The buildings, as we have already explained, have been extended by converting the old corridor into a hall about 250ft. wide, covered over with a Belfast roof. The result is that there are now about 10½ acres of floor space in one building, and there is accommodation for 900 exhibitors. Even now there is not sufficient space for all those who wished to exhibit. It is also noteworthy that arrangements are already being made for the further extension of the buildings for next year's Fair.

In our issue of February 17th we presented a Special Sixteen-page Supplement devoted to the Fair, and to-day we give one of eight pages. Even the large amount of space represented by those two Supplements would not hold the descriptions of the prominent engineering exhibits alone, and we are therefore devoting several pages to them here.

FIELDING AND PLATT, LTD.

On the stand of Fielding and Platt, Ltd., of Gloucester, there are shown two examples of this firm's most recent type of oil engine operating at low pressure with surface ignition. We illustrate in Fig. 1 the larger of the units, which has a designed output on test of 60 B.H.P., with a working load of 55 B.H.P. and a half hour overload rating of 65 B.H.P. The engine has a cylinder bore of 12¼in., with a stroke of 22in., and develops its power at 240 r.p.m. The smaller engine, which is of the same design, is rated at 30 B.H.P. on test, with a working load of 25 B.H.P. and an overload rating for half-an-hour of 33 B.H.P. It has a bore of 9in., with a stroke of 16in., and runs at a designed speed of 300 r.p.m. The engines are typical of a range of twelve engines embracing outputs from 12 to 100 B.H.P.

Our illustration shows that the engine is provided with a deep girder type of bed-plate with slightly sloped away ends, which incorporates the cylinder liner water jacket, and is furnished with a broad flange to which the cylinder head is bolted. An outstanding feature of the design is the use of a patented type of dual combustion chamber, which it is claimed enables the engine to work at a low pressure, and obviates the necessity of high-pressure fuel pumps and a complicated form of atomiser. The primary combustion chamber is bolted on to the cylinder head and valve box, and it is into this chamber that the air is compressed on the inward stroke of the engine. Between the valve box and the combustion chamber there is a communicating passage, which is of such a form as to give at the end of the compression stroke a high degree of air turbulence in the combustion chamber. The fuel oil is injected through a very simple spring valve having a plain orifice of about $\frac{1}{16}$ in. in diameter and a non-return valve. The maximum pressure in the engine cylinder does not, we are informed, exceed 450 lb. per square inch. As the highest temperatures are developed away from the air and exhaust valves, and the piston is a very long one, it is claimed that a cool running engine is obtained, and that the valves do not require any attention over long periods of running. The valves, cylinder spaces, and the combustion chamber, are water-cooled, and by means of a high-pressure lamp the engine may be started from the cold in one minute. Compressed air starting is employed on the larger engines.

As will be seen from our illustration, a mechanically-operated lubricator is provided for the piston and liner lubrication. At the end of the side shaft is the governor and fuel pump with the control links. The fuel pump is so designed that the oil is injected only at the time when the plunger is moving at its maximum speed. A hollow plunger is employed with two by-pass valves. The first valve by-passes the oil until the point of maximum acceleration is reached. The second sleeve valve is controlled by the governor, and its function is to cut off the supply of oil to the engine cylinder, to meet the load requirements. The fuel consumption of these engines varies from 0·42 lb. per B.H.P. hour to 0·48 lb. in the case of the smaller engines.

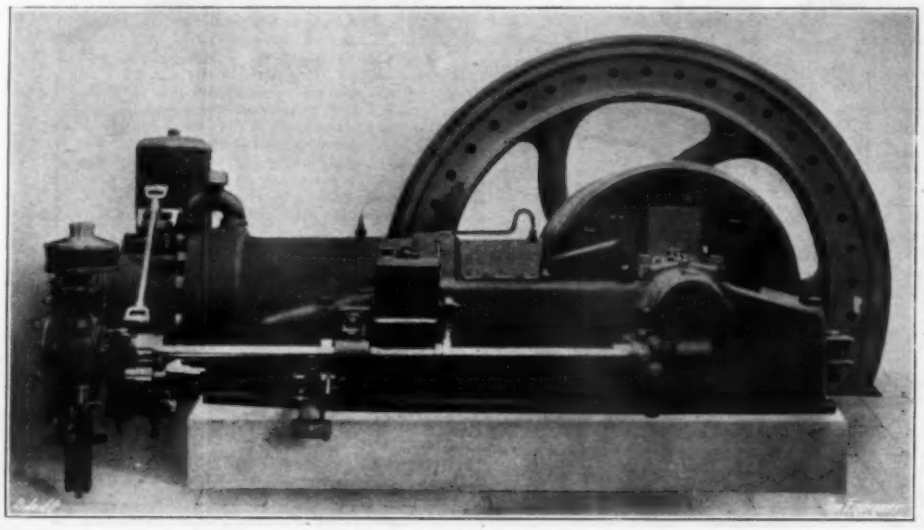


FIG. 1—60 B.H.P. COLD STARTING OIL ENGINE—FIELDING AND PLATT

FRASER AND CHALMERS ENGINEERING WORKS.

The exhibit of the Fraser and Chalmers Engineering Works of the General Electric Company, Ltd., is intended to deal only with one or two branches of the firm's manufactures which are closely identified with recent engineering progress.

In Fig. 2 we show the latest design of impact pulveriser of the Fraser and Chalmers type, which, together with the Vortex burner illustrated in Fig. 3 is displayed in the form of a small plant arranged for the firing of a Lancashire type boiler with pulverised fuel. From the drawing of the pulveriser it will be seen that the cast iron body of the machine is made in halves so that inspection and replacement operations can easily be carried out. The beaters are of the hammer type and are so arranged that their continuity of action is broken, fan action thereby being avoided so that the air passing through the beaters can flow in a direction parallel to the shaft without eddies being formed. The beaters are made of manganese steel, as are the renewable manganese steel liners which are fitted in the pulveriser body. A tramp-iron pocket is provided in the bottom of the pulverising chamber, and as the beaters are arranged to swing on the pins which attach them to their discs there is little chance of breakage by shock should foreign matter find its way into the machine.

To the left of Fig. 2 the table feeder gear will be seen. It is positively driven by chain from the pulveriser shaft and a feed plough adjustment is provided which gives a wide range of working. It is claimed that the gear enables adjustment from overload to practically zero load to be made when using fine slack, while coal with a high percentage of moisture can be quite well dealt with.

Another special feature of the pulveriser is the separating chamber, which is arranged at the top of the machine and is so proportioned that the reduction of velocity of the primary air which carries the coal in suspension is such that the heavier particles are thrown down and return to the machine for re-pulverisation. Butterfly valves are provided for regulating both the primary and secondary air streams, which meet at the top of the separator chamber and are led down to the eye of the fan. The fan is furnished with detachable carbon steel blades which are bolted to the fan disc and can be replaced. It discharges into a carefully designed volute, the discharge outlet being at the top of the machine. The pulveriser shaft is large in diameter with a high critical speed, and it is carried in self-aligning roller type bearings, a ball thrust bearing also being fitted.

We understand that the recent tests on this new type of machine, which is normally rated at 900 lb. per hour, showed that a ton of coal can be pulverised with an input of 20 kW., which has been adopted as the normal rating of the machine. The pulverisation, we are informed, appeared to be quite satisfactory, the grading of samples taken showing that 80 per cent. passed through a 200-mesh screen.

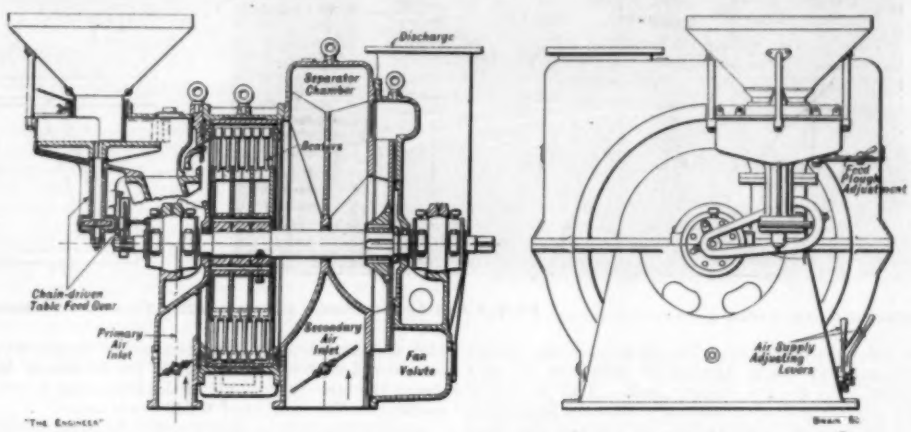


FIG. 2—IMPACT TYPE COAL PULVERISER—FRASER AND CHALMERS

The burner, which we illustrate in Fig. 3, has been designed and developed especially for use with Lancashire type boilers. It is of the Vortex type, and we understand that with it complete combustion is assured within a few feet of the furnace front. By means of an electrically illuminated sign installed on the stand a general impression of the combustion process is given.

On page 200 of to-day's issue we describe and illustrate the six-cylinder 1750 B.H.P. Fraser and Chalmers heavy-oil engine which was recently put to work in the Short's Gardens power station of the Charing Cross Electric Supply Company, Ltd. On the stand a large-scale model showing a section through one of the cylinders of the engine is displayed. It serves to illustrate the special constructional features of the cylinder head, combustion plate, and liner, and the means which are employed for the effective cooling of these parts so that the heat stresses are kept low.

FIG. 3—VORTEX BURNER—FRASER AND CHALMERS

The exhibit also includes a series of turbine wheels for Fraser and Chalmers steam turbines and turbo-compressors, which are so arranged that the workmanship can be inspected as well as the various materials which are employed in the manufacture of these parts.

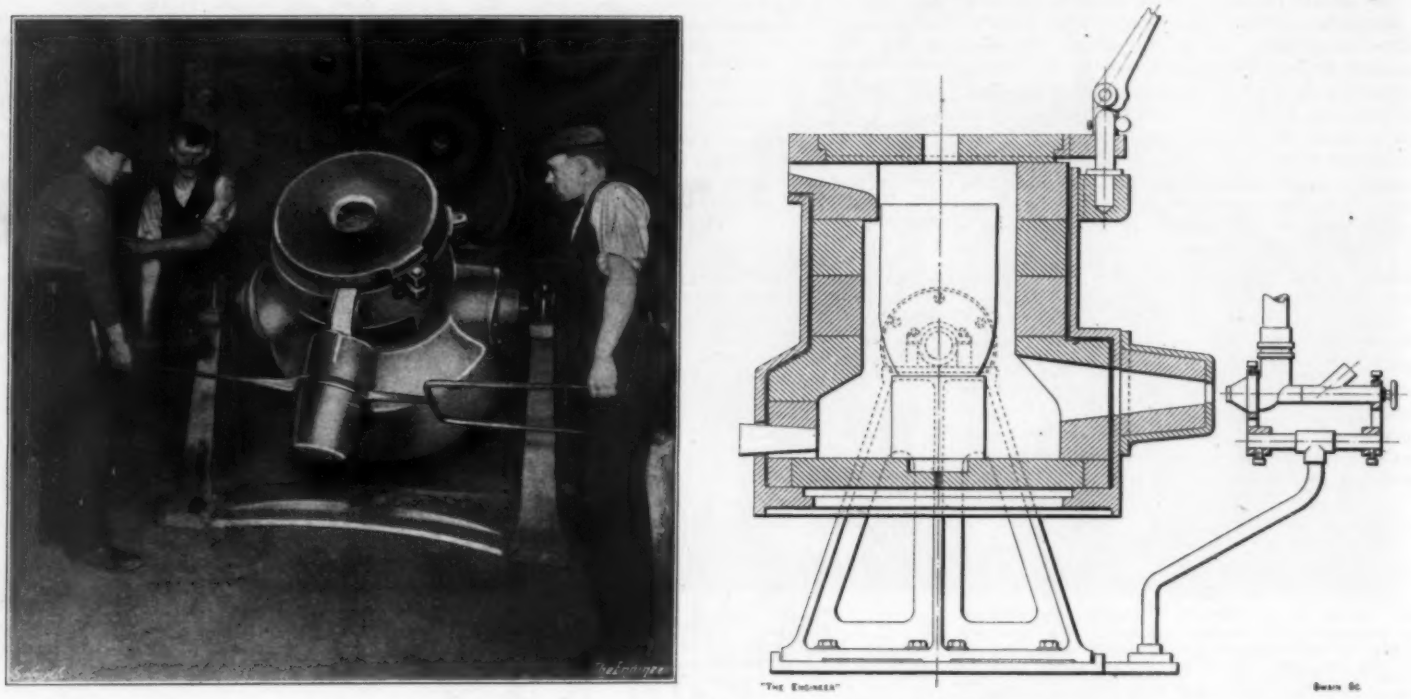
THE MONOMETER MANUFACTURING COMPANY, LTD.

An extensive range of casting machines and metal-melting furnaces is shown by the Monometer Manu-

facturing Company (1918), Ltd., of 115–116, Strand, London, W.C. 2. The firm's oil-fired central axis tilting furnace for melting brass and other metals is illustrated in Figs. 4 and 5. This furnace is built in sizes having capacities ranging from 100 lb. up to 1000 lb. per charge. The size illustrated has a capacity of 400 lb., and, it is claimed, can give one melt in 50 minutes for a consumption of not more in a special hematite iron, which is stated to be non-warping. The company states that a sheet steel or sheet iron body distorts and buckles under continued heating, with the result that the brickwork lining moves and the gannister behind it cracks. The heat then begins to burn away both the lining and the gannister and the brickwork suffers a general collapse. In the Monometer furnace the iron body is ¾in. thick, heat on to the top of the metal within the crucible.

A similar type of oil-fired furnace is made by the company for melting aluminium. In it the crucibles employed are made of a special iron alloy instead of plumbago. It is stated that a 500 lb. furnace can give a 500 lb. melt of aluminium in 75 minutes.

Among the pressure casting machines exhibited by the company, particular attention should be paid



FIGS. 4 AND 5—OIL-FIRED CENTRAL AXIS TILTING FURNACE—MONOMETER

than 5 gallons of fuel oil. The oil is fed to the burner under gravity and is injected by means of air at a pressure of 1 lb. per square inch. The burner is offset relatively to the furnace, so that the flame may enter the interior tangentially. As a result, the flame sweeps round the crucible and does not impinge directly upon it, a feature which, it is claimed, increases the life of the crucible considerably. The and the brickwork, it is claimed, remains at all times rigid and firm. Tests, we are informed, have shown that the average life of the brickwork is twelve months on the melting of 60/40 brass swarf.

A preheater can be fitted to the furnace, whereby the material can be made molten before it is introduced into the crucible. The volume of the charge can in this way be brought up to the full capacity of to the new design for dealing with aluminium and its alloys. The feature of this machine is the fact that the cylinders and plunger, whereby the molten metal is forced under pressure into the mould, are arranged horizontally instead of in the usual vertical position. It is arranged that no more metal shall be drawn into the cylinders from the surrounding bath than is required to fill the mould. In this way there is

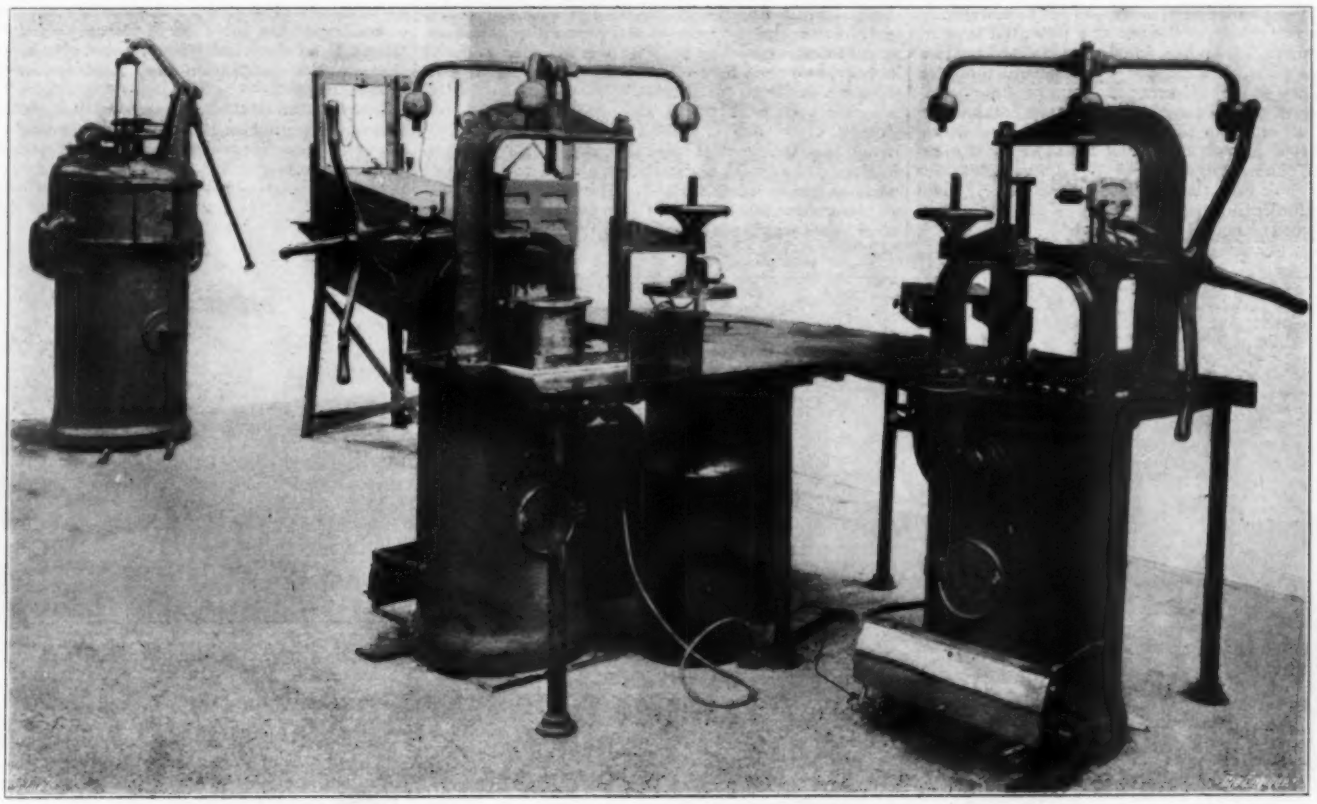


FIG. 6—PRESSURE CASTING PLANT FOR WHITE METALLING BRASSES, ETC.—MONOMETER

crucible is made of plumbago, and is distinguished by the fact that it is formed without a lip. Its upper edge, it will be seen, lies close against a lip formed in the brickwork lining of the furnace. The crucible itself, being lipless, is a standard form and can be obtained much more cheaply than a crucible that has to be made with a special size and shape of lip to suit the furnace design. The furnace body is cast the crucible. It is interesting to learn that the majority of those using the furnace prefer it without the preheater. It is stated that the furnace is more efficient and economical, and gives a greater output without than with the preheater. This result may be explained by the fact that without the preheater the furnace mouth is closed by a swivelling brick cover, which lies close to the crucible and concentrates the avoided the chief difficulty formerly experienced in the pressure casting of aluminium, namely, the adherence of surplus metal to the cylinder and plunger.

A complete installation of Monometer pressure casting plant, comprising some of the items exhibited on the firm's stand, is shown in Fig. 6. This plant is designed for the white metalling of bearing brasses, &c., and is of a type used by many railways, rolling

stock manufacturers and others. In the background to the left there is to be seen a Monometer white metal melting and refining furnace. This furnace is fitted with a mechanical disc mixer, and with a system of temperature control which prevents the metal from being overheated and burned. The metal is run out of the pot through a sprocket valve and cast into ingots. In the background adjacent to the furnace is a conveyor oven through which the old axle-box bearings, brasses, &c., are passed. In this oven the old white metal is melted out and retained for subsequent refining and re-use. The oven also serves the purpose of preheating the shells ready for the next operation, that of tinning, which follows immediately upon the shells leaving the oven. The tinning bath is incorporated in the working table on to which the shells are passed from the oven. Leaving the tinning bath, the shells are placed in the pressure casting machine. In the plant illustrated there are two such machines, one being provided for dealing with axle-box bearings and the other with bushes. In the casting machine the shell is positioned on a mandrel and is clamped centrally thereon by means of a specially designed steel box. This box, with the shell in position, is swung over and lowered on to the die. The metal is then forced in under pressure, and after it has been allowed to cool for a very short time the box and the shell are raised from the die and swung outwards through 180 deg. Ejector pins are provided to force the shell from the box. The whole cycle of operations takes about 2¾ minutes. The lining, it is claimed, is of greater density than it would have if cast in the usual way, and has a hard skin which greatly prolongs its life. No machining of the lining is required subsequently to the casting process.

BLACKSTONE AND CO., LTD.

The largest of the five oil engines of the low-compression, cold-starting type which are to be seen on the stand of Blackstone and Co., Ltd., of Stamford, is the three-cylinder horizontal model shown in Fig. 7. It has a designed output of 195 B.H.P. at 230 r.p.m. and a maximum rating for one hour of 224 B.H.P. Each of the cylinders has a bore of 12¼in. with a stroke of 22in., and the fuel consumption is 0·4 lb. per B.H.P. hour. Our engraving shows the general lay-out of the engine and the arrangement of the valves on the cylinder heads. The side shaft will be seen to the right of the illustration with the governor and fuel pump grouped together near to the crank shaft end of the shaft. An excentric drive for the mechanically operated lubricators is taken from about the centre of the lay shaft, and at the cylinder end there is a spiral gear drive to the cam shaft which runs in an enclosed casing across the top of the three cylinders. This arrangement is a most convenient one, as by its adoption it is possible to remove each combustion chamber with its valves and injection gear without having to disturb other cylinder parts.

It is not necessary to describe again the Blackstone patented spring-operated fuel injection system, as it has been fully dealt with on more than one occasion in the columns of THE ENGINEER. The system is one which gives an initial cylinder pressure of about 550 lb. per square inch at full load with a compression pressure of about 380 lb. per square inch and a mean effective working pressure of 100 lb. per square inch. A typical indicator diagram has a perceptibly flat top at the beginning of the combustion stroke, indicating that the initial cylinder pressure is not increased as the stroke proceeds.

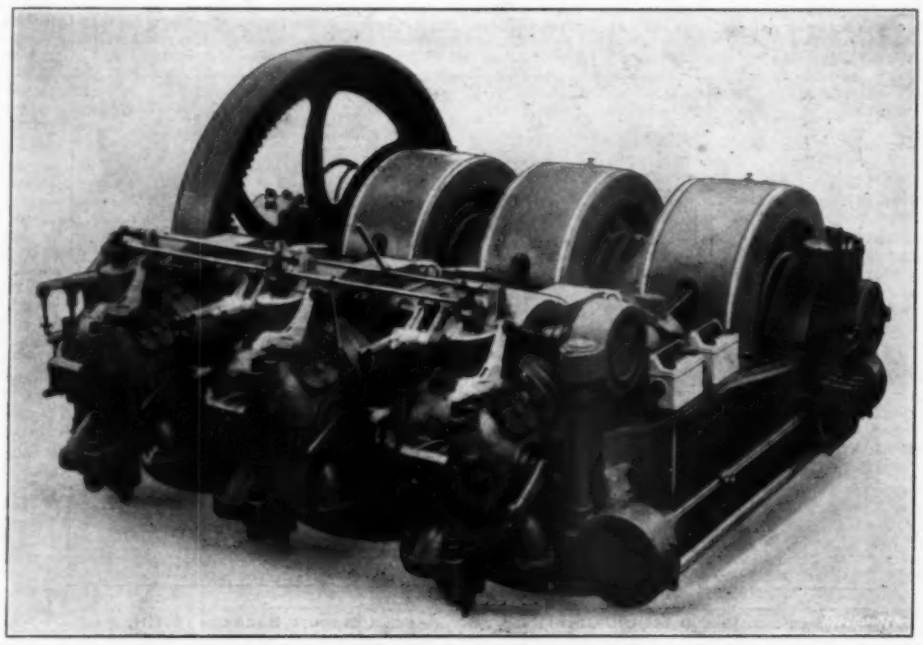


FIG. 7—195 B.H.P. THREE-CYLINDER OIL ENGINE—BLACKSTONE

The engine we have just referred to is one of the medium sizes in a range of twelve three-cylinder units embracing outputs of from 51 to 450 B.H.P. Similar series of engines include single-cylinder, two-cylinder, and four-cylinder units with designed outputs up to 600 B.H.P.

Another exhibit is the single-cylinder 150 B.H.P engine, which runs at a designed speed of 195 r.p.m. and has a bore of 18½in. with a stroke of 27in. In addition to this engine a 34 B.H.P. single-cylinder engine with a bore and stroke of 9¾in. and 17in. is also on view.

We illustrate in Fig. 8 the 3-kW oil engine-

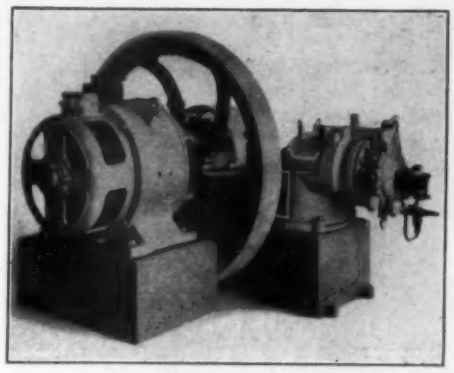


FIG. 8—3 kW GENERATOR SET—BLACKSTONE

driven generator set which is also shown. This set is typical of many engines which the firm supplies for lighting and power purposes. Two of these sets are being built for Grenada, in the British West Indies, and they each will have a rated output of 40 kW. The engine driving the generator will be a 75 B.H.P. twin-cylinder unit which is specially designed for driving alternators in parallel.

Some other exhibits include the 10 B.H.P. hopper-cooled type of single-cylinder spring-injection engine, which was described in our issue of December 9th last, along with three examples of petrol engines with outputs of 2, 3, and 5 B.H.P., which can be utilised for industrial or electric lighting purposes. There is also a representative series of the firm's patented "Unchokable" centrifugal type pumps, which are provided with a special impeller enabling them to deal with liquids containing either fibrous material or hard or soft solids. A 12in. vertical pump is shown which is similar to those in use at several sugar beet factories, and this pattern of pump has, we learn, also been used successfully for the pumping of unscreened sewage. It is designed to deal with string and fibrous matter in length up to 2ft. and to pass hard solids with a diameter up to 11in. A smaller pump exhibited on the stand is fitted with an impeller and casing lining made in manganese steel, and is so constructed for dealing with abrasive substances, such as grit, stones, gravel, and other like materials.

THE MIRRLEES WATSON CO., LTD.

The principal exhibits on the stand of the Mirrlees Watson Company, Ltd., Glasgow, comprise a series of centrifugal pumps along with a Mirrlees-Leblanc air injector and some component parts. The largest pump displayed has an output of 800 gallons per minute at 50ft. head, and is a 6in. split casing pump, with a double suction impeller, designed to run at 1440 r.p.m. As the pump cover is removable, all internal parts may be inspected. There is also shown a 1½in. bore pump with a single suction impeller, which is one of a range of small pumps that the firm has introduced for industrial purposes.

A typical example of a steam operated air ejector is also displayed. This type of vacuum-producing apparatus is largely used in modern condensing practice on account of the high vacuum which can be maintained by it with a low steam consumption.

Among other models is one of a sextuple-effect evaporator, illustrating a plant similar to that shown in Fig. 9. The large size of such a machine does

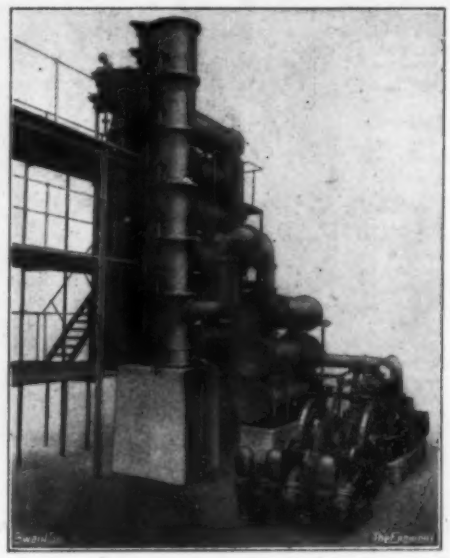


FIG. 9—SEXTUPLE-EFFECT DISTILLER—MIRRLEES

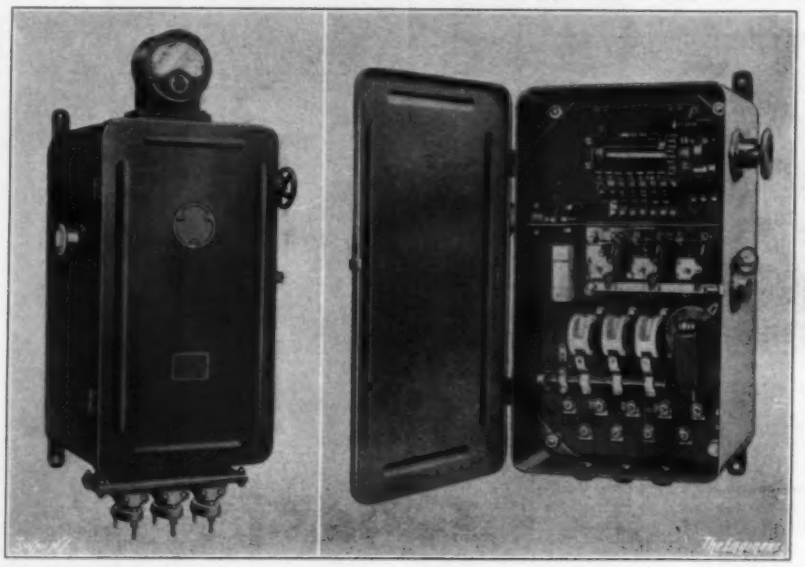
not permit of it being displayed on the stand other than in model form. Over seventeen of these evaporators have been installed by the firm along the shores of the Red Sea, and are used for distilling fresh water from the only available supplies of sea water or brackish water. Two notable installations are those at the ports of Jeddah and Yembo, which supplies drinking water to the pilgrims going to Mecca and Medina. The yield of 36 lb. of fresh water for every pound of coal is obtained, and if oil is employed as the fuel, the output of fresh water is increased to 40 lb. per pound of oil burned. The firm's specialities in the manufacture of sugar machinery, chemical plants, steam-condensing plants, and pumping installations are illustrated by a selection of photographs and drawings.

THE BRITISH THOMSON-HOUSTON COMPANY.

Horizontal and vertical type motors are exhibited by the British Thomson-Houston Company, of Rugby. A special feature of these machines is that the main dimensions of the alternating-current and direct-current motors are of the same rating and identical. They are constructed to run at any angle, and a roller bearing is fitted at the driving end, where the load is greatest, and a ball bearing at the other end. Fractional horse-power motors shown are claimed to be the smallest motors made for their rated outputs. There are many types of control gear for alternating and direct-current motors ranging from 15 to 100 horse-power. The control panel shown in Fig. 10 is for non-reversing slip-ring motors up to 30 horse-power at 600 volts. Over-current and no-voltage protective gear is provided and the motor can be stopped at a distant point by means of a press button.

The pressed sheet steel case contains a drum type starting switch, a contactor type circuit breaker with an under-voltage release which opens all three phases of the stator circuit, a "dead man's" handle and a thermal current relay in each of the three phases. The drum type starter, which is operated by a hand wheel on the right-hand side of the panel, consists of a cylinder with renewable contact segments, each of which engages with a separate finger of the controller pattern with renewable arcing tips. The triple-pole contactor type circuit breaker has arc chutes, blow-outs and renewable arcing tips, and is particularly designed for arduous duty. After an overload it is only necessary to bring the starting switch to the "off" position in order to re-start the motor. To stop the motor the starting handle is returned to the "off" position, when, by means of an interlock, the operating coil circuit of the contactor circuit breaker is interrupted and the breaker opens immediately the starter leaves the running position, thereby cutting off the power supply to the motor. Inching can be obtained by alternately depressing and releasing the "dead man's" handle, when the starting switch is in the "start" position, or the operation can be carried out by means of press buttons. A view of the panel with the front of the case open is shown in Fig. 11.

An interesting exhibit is the ironclad oil-immersed triple-pole circuit breaker shown in Figs. 12, 13 and 14, with "on" and "off" push-button control. This type of circuit breaker is intended mainly for use with three-phase induction motors on circuits working at pressures up to 660 volts and has been designed with the object of providing a cheap and reliable form of protection which will enable the motors to carry heavy overloads for short periods, but which will disconnect them on sustained overload as well as at times of irregularities in connection with the supply or motor.



FIGS. 10 AND 11—CONTROL PANEL FOR SLIP RING MOTOR—B.T.H.

Whilst a momentary starting current of five or six times the normal current is safely carried without the breaker tripping, an overload cannot persist for long enough to cause injury. An open circuit on one phase will cause the breaker to trip before the motor can become overheated by operating as a single-phase machine, and in the event of a short circuit occurring in the windings or leads the motor is immediately disconnected, and it is also disconnected in the event of a failure in the supply. All the parts can readily be inspected, notwithstanding that the apparatus is very compact. The 30-ampère size of breaker is

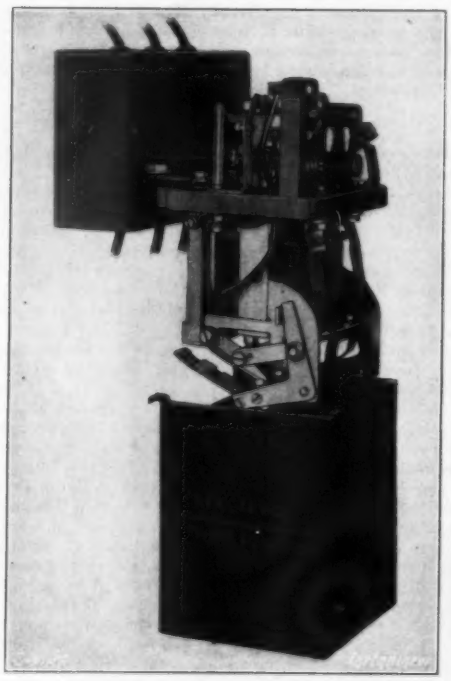
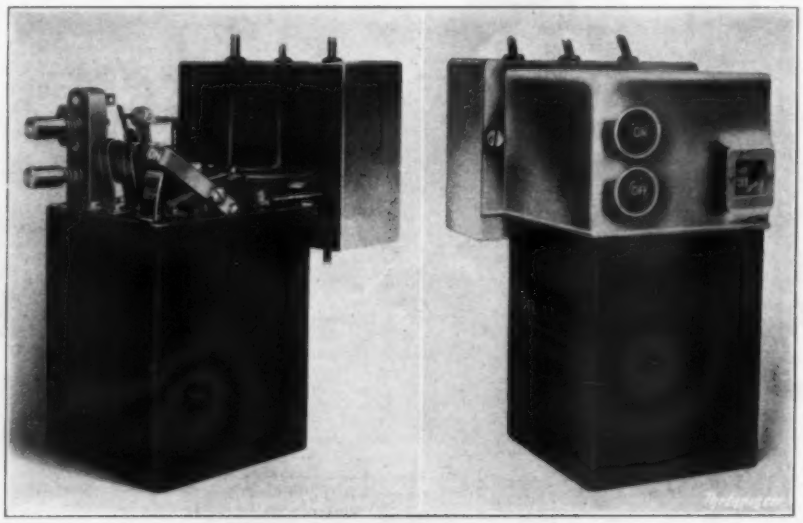


FIG. 12—THERMAL CIRCUIT BREAKER—B.T.H.

about 8¾in. high, 7⅝in. deep, and 16in. wide. The mechanism is mounted on an insulating base, fastened to a connection chamber in which there is ample room for the various types of cables in use. To this cable connection chamber the oil tank is attached and it is held in position by the top cover of the circuit breaker. The moving and fixed contacts are of the contactor type and renewable sparking tips are fitted. Contact is made by a wiping action and no arcing takes place on the contact faces when the circuit is broken. When required, a moving iron ammeter can be mounted on top of the cable connection chamber. The breaker is controlled by "on" and "off" push buttons with spring releases. The push buttons can either be mounted on the breaker case, as in Fig. 14, or may be fixed at distant points. They can also be incorporated in the rotor starter so that the breaker is closed automatically when the first contact on the starter is made. The breaker is closed by the "on" push button, which completes the energising coil circuit, which is connected across two phases of the main circuit. This coil exerts a pull on the armature, and by means of a toggle mechanism a quick positive contact is made between the fixed and moving contacts. By means of an auxiliary switch fitted to the middle moving contact a retaining coil circuit is completed at the moment of closing the breaker so as to retain the armature. The operation of the "off" push-button switch disconnects the energising coil from the main circuit when the armature is immediately released and the breaker contacts separate with a quick break action. An indicator gives indication of whether the circuit breaker contacts are open or closed.



FIGS. 13 AND 14—OIL-IMMERSED TRIPLE-POLE CIRCUIT BREAKER—B.T.H.

The automatic features are obtained by a combination of a three-phase magnetic circuit overload element and a thermostatic arrangement giving the time limit. The overload element is energised by one series turn per phase, and when the armature is attracted to its closed position it actuates the "off" push button switch and the breaker is tripped. Bi-metallic thermo strips connected in each phase have a bending characteristic which is proportional to the current, and in bending they engage with the armature of the overload element. After the strips have moved sufficiently to decrease the air gap, the magnetic pull on the armature, due to the overload current, causes quick action and a break of the energising circuit and consequently quick tripping is obtained. By a simple adjustment the breaker can be set to suit different sizes of motors. At present the standard sizes of breakers of this type are for 30, 60, and 100 ampères.

Another new development is an ironclad oil-immersed double-break circuit breaker for three-phase circuits working at pressures up to 660 volts, and a view of this breaker is shown in Fig. 15. Like the thermal circuit breaker, it can be mounted on a machine or on a wall or on a pedestal framework. It can be provided with a mechanically interlocked isolator, two or three over-current series trips, with or without fixed or adjustable time lags, and an under-voltage release which can be electrically interlocked with a motor starter. Standard cable and conduit fittings suitable for various arrangements of single and three-core armoured or non-armoured cable can be supplied. Each set of blocks for the fixed contacts is attached to a bar of insulating material which is held rigidly in position by hexagonal posts fastened to the breaker frame. The fixed contacts are of a novel contactor pattern and the contact

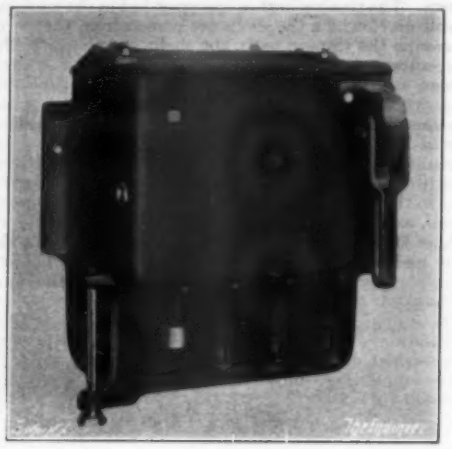


FIG. 15—IRONCLAD CIRCUIT BREAKER—B.T.H.

pressure is maintained by strong compression springs which ensure a very low contact resistance. As the cable sockets are bolted and locked to substantial extension strips attached to the contact blocks, flexible tails are eliminated. The moving self-aligning inverted "U" type moving contacts have sparking fingers which are reinforced by steel backing springs and fitted with renewable sparking tips which engage with fixed contact sparking tips of similar design. A single motion of the operating handle serves for opening and closing the breaker, and the handle can only be left in the full "on" or full "off" position. If desired, a device for locking the handle in the "off" position can be supplied, and, as the travel of the handle is limited by a stop, there is no possibility of the contacts being overstrained. The operating mechanism is simple and it is fitted with a roller catch arranged so that the free handle trip is effective throughout the complete stroke from the "on" to the "off" position. Strong accelerating springs assisted by gravity ensure that a high initial speed of break is obtained.

(To be continued.)

ENGINEERING surveys have indicated that two-fifths of the power possibilities of the English River, Canada, or some 212,000 horse-power, lie in Ontario, while the balance lies in Manitoba. The construction of a dam at Ear Falls on Lac Seul is essential to the securing of power for Ontario and to the securing of further power for Manitoba, where there are already power developments on the Winnipeg River which would be benefited by the regulation of the flow of English River. The proposed dam will raise the head of Lac Seul some 11ft. or 12ft. It is estimated that its cost will be in the neighbourhood of 500,000 dollars.

Railway Matters.

THE London Electric Railways Company is taking steps to allow tramcars to run into the yard of Golders Green Station. To appreciate this unusual co-operation between railways and tramways it should be noted that the tramcars are not those of the London County Council but of undertakings in which the "Underground" is interested or with which it works.

THE difficult question of statutory bridges over railways and canals would appear to be near settlement. By the Bridges (Improvement and Maintenance) Bill such bridges are to be taken over by the local authorities, and the responsibility for the railway and canal companies will then cease on their payment of a lump sum each year. The local authorities may then, where necessary, reconstruct or strengthen them to suit present-day needs instead of, as now, the bridges being only of sufficient strength to carry the traffic of the period when the bridges were built.

A VERY practical debate on the motion of a Labour member in favour of stricter control over road traffic took place in the House of Commons on the 15th instant. At the close Colonel Ashley, the Minister for Transport, accepted the motion and promised a Government inquiry into transport problems. He said, however, that the terms of reference would require careful consideration, and no inquiry could be allowed to prejudice the discussion of the railway Bills for the opening of the roads to the goods and passenger traffic of the railway companies, nor would it be allowed to postpone the Roads Traffic Bill of the Ministry of Transport.

IT is announced that the new all-electric signal box at London Bridge will probably be opened in June. It will contain 311 levers and all the signals will be of the day colour light type, as used at Charing Cross and Cannon-street. Five existing signal-boxes which to-day contain 615 mechanically-operated levers will be displaced. The Southern Railway, in making this announcement, claims that it is the largest of its kind in the world. We would, however, point out that the power locking frame at Glasgow Central Station has 374 levers. But there is this difference—that the latter is on the electro-pneumatic principle. The locking frame at London Bridge, it may be added, is being made and supplied by the Westinghouse Brake and Saxby Signal Company, but fixed by the railway company's own forces.

WHEN the three companies that now form the Southern Railway were grouped, two of them had the vacuum brake as their standard, and it was therefore not a matter of very great moment to decide that the locomotives and coaching stock on the Brighton section should have the Westinghouse brake replaced by the vacuum. With the London and North-Eastern Railway a more serious decision had to be made, as the Westinghouse was the standard on the Great Eastern, North-Eastern, North British and Great North of Scotland, and thus practically one-half of the 7500 locomotives and 20,400 coaches on the L. and N.E.R called for conversion. There were also 1100 engines and 4700 carriages fitted with both brakes. It has now been decided that the vacuum shall be the standard and the Westinghouse be withdrawn. The work will take four years to complete.

IT is officially announced that Mr. E. Prebble, the district engineer at Watford, London, Midland and Scottish Railway, has been removed to headquarters at Euston to be Assistant Engineer (Permanent Way), and that Mr. A. Wood-Hill has been transferred from the Camden Town district to Watford to succeed Mr. Prebble. The position of permanent way engineer in the old London and North-Western days and since has, from the time when Mr. Harry Footner held the office, been operative from Crewe, and the present chief civil engineer, Mr. A. Newlands, occupied that post at Crewe until he was promoted, a year ago, to succeed Mr. Trench. It would therefore seem evident that Mr. Thornhill's removal from Bangor to Crewe—mentioned in this column on January 6th—was to act as the Crewe divisional engineer only and not also as permanent way engineer.

AT one time all the points on the Midland Railway were actuated by wire, a weight at the points keeping the wire taut. As a result of many derailments the replacement of wire movements by rod actuation for all points on passenger lines was ordered some fifty years ago and that work was completed just prior to the Act of 1889, which compelled the concentration and interlocking of points and signals. Wire working was, however, retained in the marshalling yards at Toton, Chaddesden, Bowsley, &c. Of recent years it has been appreciated that on the Continent points and signals are effectively operated by a double—outward and return—wire, and the Midland section of the London, Midland and Scottish Railway has paid particular attention to the new method, and now six installations, of a total of ninety levers and sixty-two sets of points, are in operation, and four further plants, totalling 105 levers and sixty sets of points, are in hand.

THE railway dividends announced a week ago indicate considerable economies in operation by the various companies. The London, Midland and Scottish pays 4¼ per cent. for the year, and carries £58,000 forward. For the abnormal year of 1926 it had to take £7,437,370 from reserves in order to pay 3 per cent., and when 6 per cent. was paid in 1925 £1,646,673 was withdrawn. This year the whole is paid out of current receipts. The published traffic returns showed a slight total decrease, it is estimated, of the amount of £1,500,000. As the Southern is so dependent upon passenger traffic the bad weather of last summer and also road competition seriously affected its business. The dividend on the deferred ordinary shares is 2 per cent. In 1925 £212,948 was withdrawn from reserves to pay 3½ per cent., but in 1926 a sum of £927,507 was wanted to pay 1½ per cent. The Metropolitan has not yet got back to its 5 per cent., but pays 3 per cent. as in 1926. But for the latter £100,000 was drawn from reserves, whereas now £10,000 is placed to reserve. The published traffic returns showed an increase of £93,000, but the net receipts are up by £143,000, which indicates economy. The Metropolitan District divided 4 per cent., as compared with 3½ per cent. in 1926.

Notes and Memoranda.

NICKEL chrome cast irons are, according to *Machinery*, now being increasingly used for the making of automobile cylinder blocks, and it is only a question of time before they are used for other purposes.

THE number of passenger motor cars in Ontario in 1927 was 343,992, while the population is approximately 3,000,000. The number increases from 30,000 to 40,000 each year, the number of passenger cars in 1922 having been 210,333.

OFFICIAL estimates place the available merchantable stand, including saw material, pulpwood, poles, cordwood, &c., of Canada, at 246,000 million cubic feet, which is roughly 100 times the annual cut for all purposes, and 50 times the annual cut and wastage—through fire and insects—combined.

IT is, says *Machinery*, very common to overhear it remarked that a steel component has failed in use owing to its having crystallised. If the fracture of the part is coarsely crystalline this explanation is often forthcoming in the shops. The fact is that neither steel nor any other metal or alloy can crystallise at ordinary temperatures such as those at which the part is likely to function.

IN the *Chemiker-Zeitung* of December 31st, Professor Neumann gives an interesting account of some analyses which he has recently carried out of fragments of Babylonian artificial lapis lazuli, dating from about 1400 B.C., from the excavations at Nippur. The high percentage of lead previously found by Bertrand has been shown to be quite erroneous, but it has been conclusively established that both cobalt and copper are present as colouring matters. It is claimed that this is the only antique glass which is definitely known to be coloured by cobalt.

IT is stated in *Chemistry and Industry* that Dr. W. Pfanhauser, director of the Langbein-Pfanhauser Werke, has been drawing attention to the application of cadmium as a rust protector. Cadmium has been widely used in galvanising iron, as well as a substitute for silver in silvering, its electrolytic deposition being simple. When protection over long periods is needed, it has often replaced zinc, because it gives the same resistance to corrosion with thinner coatings, while it is more resistant than nickel, though somewhat inferior to it in mechanical properties.

IN the latest report of the Fuel Research Board on the Wigan Four-feet Seam, it is stated that the available resources of the proved coalfield have been estimated at 4240 million tons. The lower coal measures contain two or more important seams of coal, which, together with the associated valuable fire-clays, render the subdivision of more than usual importance. A reserve approaching 190 million tons of easily reached coal is attributed to these seams. South of the Lancashire coalfield and over the Cheshire Plain, there extends a buried coalfield, of which the structure and depth are unknown.

A CABLE message from New York states that the development of a 900,000-volt cathode ray tube, which is regarded as an important step towards the production of artificial radium radiation, is announced by the General Electric Company of America. The new tube is nearly 8ft. long, and has three bulbs, each a foot in diameter, which receive their supply of electrons from a heated tungsten filament. It is hoped that the discovery will help to increase the knowledge of radiation laws and the nature of the nucleus of the atom, and that eventually therapeutic, chemical, bactericidal and other practical uses will result from it.

NEARLY 95 per cent. of the present world production of commercial potash is derived from the soluble potash-salt deposits of Germany and France. The estimates of German potash reserves vary from 22,000 million to 3,840,000 million short tons of crude salts. The French reserves are estimated at approximately 1600 million short tons. The recently discovered deep deposits in Texas and New Mexico are believed by competent geologists and engineers to contain many millions of tons of soluble potash salts. They are being extensively prospected by drilling, with a view to developing a source of supply which, with potash derived from Searles Lake and other sources of brine, should render the United States less dependent upon the present Franco-German monopoly.

IN a paper on "Low Temperature Carbonisation," read before the Manchester Geological Society, Mr. C. Turner described the process of making "Comac" fuel, and said that during the summer it became evident that the fuel was improved by allowing it to soak in the superheated steam. Leaving it soaking in the retort materially reduced the throughput of the retort, but the strength of the fuel was very much improved. So to increase the throughput capacity of the retort, whilst continuing to make this strong fuel, a distance piece 7ft. long was put in between the flanges forming the joint between the retort and the bottom hopper. This had of necessity to be cylindrical. A continuation of the conical retort would have been preferable. The change produced the results expected of it. Although the retort is now 14ft. in depth the solid fuel shows no evidence of having been crushed. The throughput now exceeds 10 tons per day of twenty-four hours.

PROMISING attempts to dry grain by means of electric power have been carried out by the Swedish Waterfalls Administration during the past autumn. The method tried was invented by Mr. H. Edholm. The drying equipment has, says *Swedish Export*, a capacity of about 8 tons, and consists of a fan in connection with an injector and a discharge tube, which latter at the upper end opens out on a number of inclined boards for the airing of the grain. The air current from the fan forces the grain gradually up through the tube and on to the boards. The boards being inclined at an angle closely approximating the friction angle of the grain, the latter descends slowly towards the silo. The air current used to raise the grain is in the meantime carried off between the boards and therefore subjects the thin layers of grain to an effective airing. In this way the grain can be circulated once a day or oftener according to requirements. The consumption of current is from 2 kWh to 3 kWh per 2 cwt. of grain. Under normal conditions the above operation is sufficient for drying the grain down to 16 or 17 per cent. of water.

Miscellanea.

A SUGAR factory with a capacity 775,000 tons a year is to be put up at Sarnia, Ontario.

THE proposal to establish a beet sugar factory at Blunham (Bedfordshire) has been abandoned owing to the required acreage of beet not being guaranteed by the farmers.

A COMPANY has been formed in South Africa, with the title of the South African Radium Corporation, and a capital of £60,000, to work the pitchblende deposits of Cape Province.

A MORE active policy of road construction is in contemplation by the Government of Uruguay, and probably later of State railway building also. The country is also being surveyed, with a view to schemes of afforestation.

THE Portuguese Government has awarded to Duncan Stewart and Co., of Glasgow, the contract for the installation of a sugar refinery at Umbelugi, in Portuguese East Africa. The value of the contract is estimated at between £270,000 and £300,000.

IN the first year of operation of the new Dominion Government Dry Dock at Esquimalt, British Columbia, the revenue collected amounted to 19,306 dollars, although the dry dock was not officially opened until July 1st. The total number of vessels docked during the year was 18, with a tonnage of 86,480.

THE mechanical pulp mill to be erected at Edmundston, New Brunswick, by the Fraser Companies, will have a daily capacity of 150 tons, and the paper board mill there will have a capacity of at least 60 tons daily. The extension to the sulphite pulp mill will increase its capacity from 160 tons to 260 tons daily.

NOVA SCOTIA Tramways and Power Company proposes to erect in Halifax the first coking plant subsidised under the Federal Government's Domestic Fuel Act of the last session of Parliament. The coking plant will replace the Tram Company's present gas-making equipment. The estimated cost is 160,000 dollars.

THERE was a marked increase in the gas and oil production of the western fields of Canada during last year, the output of oil reaching 329,000 barrels, while the production of gas for consumption totalled nearly eleven and a-half billion cubic feet. The 1926 figures for oil were 219,000 barrels and for gas nine and a-half thousand million cubic feet.

TRADE Unions and employers are supporting the formation of an Engineering Council for the London district, and a meeting to inaugurate the venture will be held on February 27th. The object of the Council will be to improve relations between workers and employers, and to promote social gatherings. It will not deal with wages or conditions.

SURVEYS are being made for the construction of a 25,000 horse-power plant on the Montreal River, for the Great Lakes Power Company, while the plans of the Hydro-electric Power Commission of Ontario include the development of 12,000 horse-power on the St. Mary's River, from 125,000 to 140,000 horse-power on the Mississauga River, and 30,000 horse-power on the Montreal River.

AN outstanding feature of the latest report on the Canadian metal industries is that exports of aluminium in 1927 were more than double those of the previous year. For the calendar year 1927, the report shows exports of aluminium in blocks, &c., as 51,902,400 lb., valued at 10,544,195 dollars, compared with 25,177,000 lb. valued at 5,900,547 dollars in 1926. This metal now ranks fifth in value in the exports of Canadian non-ferrous ores and smelter products.

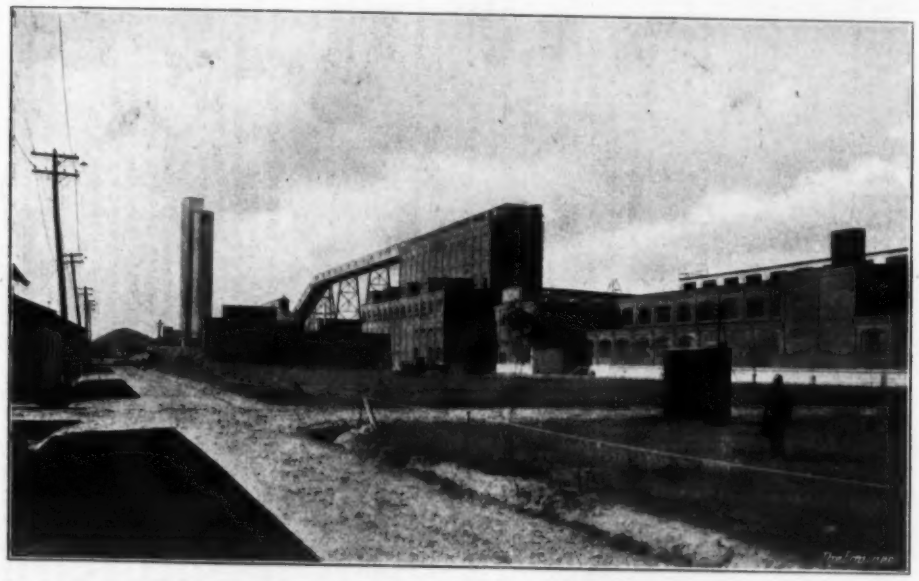
THE Swedish newspapers report that a new company is being founded to exploit the Flodin-Gustafsson methods for the direct electric production of forgeable iron and steel and stainless iron and steel. The capital of the company, the name of which will, it is said, be Flodin-Jaern Aktiebolag, is fixed at Kr. 8,000,000 mimimum and Kr. 24,000,000 maximum. It is stated that trials of the method at the Uddeholm, Forshaga and Fagersta Ironworks have yielded quite satisfactory results.

ON the occasion of an informal meeting at the Hotel Cecil, on Wednesday, the 15th inst., Dr. P. Dvorkovitz, who is associated with the Rational Carbonisation Syndicate, raised a plea for the independence of this country from other countries in the matter of oil supplies, and explained how it was wrapped up with the coal industry. He urged that there should be instituted local organisations for marketting the coal and for raising funds with the object of improving its raising, sorting and washing before it is supplied to the consumers. At present, according to the Royal Commission, there were at least 50,000,000 tons of wastage and loss in the form of slack and smalls. Amongst the various suggestions made for the purpose of utilising that waste there were, he said, the following:—(1) Utilisation of some of the waste for the purpose of creating electrical power for the super-power stations: (2) Extraction of the petroleum from the coal and utilising the residue as smokeless fuel, or as powdered fuel, or transforming into complete gas.

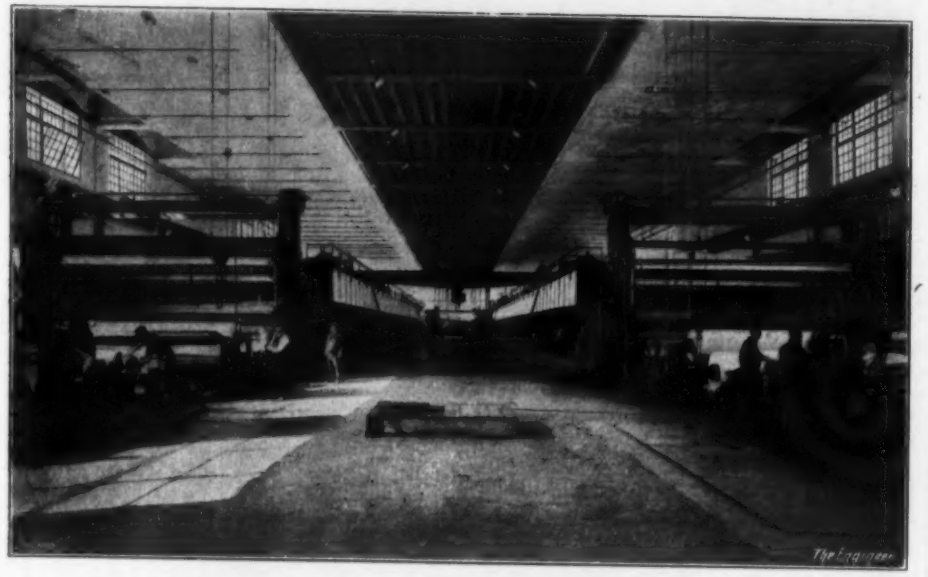
EXCLUDING gold bullion, the exports of all other Canadian non-ferrous ores and smelter products in 1927 were valued at 79,468,579 dollars, compared with 75,693,361 dollars in 1926. Nickel rose from fourth place in 1926 to first place in 1927, with exports valued at 13,680,834 dollars, compared with 12,460,884 dollars in the previous year. Canada exported 127,111,200 lb. of copper in 1927, compared with 112,422,800 lb. in 1926. Lead exports totalled 255,995,900 lb., compared with 216,155,200 lb. in 1926. Zinc spelter exported in 1927 amounted to 112,420,400 lb. compared with 96,008,100 lb. in 1926 and zinc ore to 25,227 tons, compared with 41,917 tons in 1926. Exports of silver ore, concentrates and bullion in 1927 totalled 21,416,078 oz., compared with 21,132,133 oz. in 1926. Exports of cobalt showed a great increase in both quantity and value over 1926, the total value for this metal in 1927 being 950,450 dollars, compared with 540,237 dollars in 1926. Small amounts of platinum, molybdenum and other metals were also exported during the year.

THE WEST TEMPLETON PAPER MILLS ON THE OTTAWA RIVER

(For description see page 216)



ACID AND SULPHITE PLANTS WITH PART OF MACHINE ROOM NO. 1



INTERIOR VIEW OF ONE OF THE PAPER MACHINE ROOMS

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SYNCHRONOUS MOTORS WHICH DRIVE THE GRINDSTONES

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The Metallurgist

THE FEBRUARY NUMBER OF THE MONTHLY METALLURGICAL SUPPLEMENT TO "THE ENGINEER" ACCOMPANIES THIS ISSUE.

THE ENGINEER.

FEBRUARY 24, 1928.

Waste Heat Recovery.

THE instructive paper on waste heat recovery which Major William Gregson presented on Friday evening of last week before the Institution of Mechanical Engineers should serve to arouse in many quarters an extension of interest in the utilisation of waste, or surplus, heat. It is well known that abroad much more attention has been paid to this subject than we in this country have so far given to it. In the past plentiful supplies of cheap, good coal rendered us, or so many thought, superior to the necessity for getting the last out of our fuel; of making good and efficient use of every possible heat unit which we could obtain from it. Abroad countries, less fortunately situated than ours in the matter of fuel supply, took an interest in the subject at an early date, and have now undoubtedly surpassed us in the effective use of waste heat. In a few trenchant remarks at the close of the discussion on his paper, Major Gregson commented upon the folly of the belief, widespread among our British manufacturers, that in the fulness of time economic conditions will revert from their present stressful state to that which characterised them in pre-war days. There are factors which have definitely changed, and which we cannot, in reason, expect ever to return to what used to be their normal value. Our industrial history should discourage anyone from believing, and acting on the belief, that the cost of labour and materials will fall permanently to, or below, the level of the years before the war. Even although those costs did so fall, the foreign manufacturer would not abandon the advantages which he has acquired by paying attention to the improvement of the efficiency of his methods, among which the utilisation of waste or surplus heat takes a very high place. Hence, the British manufacturer cannot afford to despise the gain to be secured by the recovery and employment of waste heat. No matter how good and plentiful his coal supplies may be, no matter whether he is right or wrong in his belief that eventually a fall will occur in the cost of his coal, materials and labour, it is imperative that he should place himself abreast of his foreign rivals by making full use of the heat contents of his fuel.

In his paper Major Gregson argued that hesitation to adopt waste heat recovery plant in this country could be ascribed to incomplete knowledge regarding its exact scope, to excessive stress being laid on the troubles encountered with pioneer plants, to the effects of exaggeration, in certain quarters, of the possibilities of regeneration, and to the understandable disinclination of furnace and engine builders to admit that their furnaces or engines "wasted" any heat that might be recovered. There are, however, other reasons for the comparative apathy to waste heat recovery shown in this country, and the cause of regeneration will be assisted by their frank recognition. It is easy to take the outstanding example of a steel works, and, analysing the various processes from the conversion of the coal into coke to the rolling of the ingots, to show, as Major Gregson has done, that the coal fed into the coke ovens contains by itself sufficient available heat to supply all the heating and power required throughout the works. That fact has been demonstrated by others before, and is already well known in the steel industry. Why, then, is it not generally put into practice? The reason is a fundamental one. To take full or even large advantage of the heat recovery possibilities in the production of steel, there have to be gathered together on one site and under one control several distinct branches of industry, which have had separate origins at separate dates. The complete balancing of the thermal account requires the close grouping of the coke ovens, by-products plant, blast-furnaces, melting shops, and rolling mills. Were it possible to start all over again, we should probably find every steel works organised on a self-contained basis, making its own coke and smelting its own iron, and taking full advantage of the surplus heat units liberated during one stage for the conduct of the succeeding stages. A few particularly favoured steel works have found it possible to organise themselves in this way, but in general the fact has to be faced that to take advantage of all the possibilities of waste heat recovery in a steel works there must be expended on general reorganisation an amount of capital of which the cost of the waste heat boilers and other regenerative equipment forms only a very small part. Major Gregson estimates that full waste heat recovery in a steel works should reduce the fuel bill from about 65 cwt. down to about 35 cwt. of coal per ton of "finished" steel. That some such tremendous saving of fuel may be possible we will not dispute, but that this saving is only one side of the picture seems to be established by the fact that, so far, steel works operating on the fully regenerative principle have not swept the field clear of their non-regenerative rivals. That attention ought not to be focussed solely on the amount of fuel saved is amply demonstrated by Mr. Benjamin Talbot in a letter to *The Times* for February 13th. Mr. Talbot, like Major Gregson, takes 35 cwt. of fuel per ton of finished steel as the ideal consumption, but to realise that figure, he says, would mean the entire or partial scrapping of the greater number of existing iron and steel works, the loss of much of the present capital invested in the industry, and the raising of considerably larger amounts of fresh capital. One of the works under his control is at present producing a ton of finished steel for a consumption of 41 cwt. of fuel. He would be delighted, he says, to own an ideal plant if he could obtain it otherwise than by borrowing millions of money on which he could see no adequate return. The case established for waste heat recovery in gasworks illustrates a second fundamental feature of the subject. According to Major Gregson, if all the gasworks in this country adopted full waste heat recovery practice, they would be able to generate from their waste heat 9,000,000 tons of steam per year. That figure is equivalent to about one-eighth of the total steam consumption of all the electricity generating stations in Great Britain during the year ending March 31st, 1927. It is obvious that the steam which might be generated is far in excess of what the gasworks themselves could employ. With full heat recovery the works would be in the position

of manufacturing a by-product for which they would require to find a market. This consideration, no doubt, lies behind Major Gregson's brief, but significant, remarks concerning the desirability of linking up, under one control, the electricity supply and gasworks in every town. The linking up would require to be no mere figure of speech, but an actual physical fact. In a minor way, the utilisation of waste heat on motor-driven ships illustrates the same point. From the exhaust of the engines about 1 lb. of steam per hour can, it seems, be generated per brake horse-power. If we omit the employment of the steam to supplement the power of the main engines, as in the Still system, the problem of finding a profitable outlet for the by-product is not easy to solve economically or satisfactorily. It is certain that at some periods of the year, or at some stages of the voyage, the steam will be in excess of the requirements of the ship's auxiliary services, and at other periods or stages totally deficient. To meet the first condition it is necessary to design the waste heat boilers in such a way that they can be run dry and be used merely as silencers. To meet the second condition, the waste heat boilers must be equipped with independent firing arrangements, or, as Major Gregson recommends, be supplemented by duplicate independently fired boilers.

One or other of these considerations will be found to apply to a greater or lesser extent in nearly every scheme for the recovery of waste heat, whether it be for a metallurgical, cement, brick, pottery or chemical works. In general, the extent to which waste heat can be profitably utilised requires close investigation on the spot. In general, it will be found to stop a good way short of the maximum physically possible extent. Some of the waste heat must either continuously or at certain periods be allowed to go to waste if respect is to be paid to all aspects of the annual balance sheet. That admission is, however, no reason why we should fail to take advantage of the portion of the waste heat which can be profitably utilised. Up and down the country there are many such portions which, it is certain, are being thrown away, possibly in ignorance or apathy, or because the gain to be secured has never been closely investigated with the care and expert knowledge which the subject demands. The practice of waste heat recovery is far less a matter of the design and manufacture of suitable waste heat recovery equipment than of the careful study on the spot of all the technical, commercial and financial considerations which are involved in it.

Furnaces of Large Boilers.

THE most insistent problem which confronts the boiler-house engineer at the present time is the maintenance of his furnaces. The high temperatures typical of modern operating conditions are, of themselves, sufficient to try the brickwork to the utmost, and when to these is added the destructive effect of molten ash dust there is no refractory known which will stand for long. It is indeed the inadequacy of refractories which now puts a limit to temperatures and makes it necessary often to renounce the full advantages of preheated air. The question of furnace construction first became acute with the development of powdered fuel firing, for not only were the furnaces vastly larger, but the whole of the wall surface was exposed to the attack of the ash in the fuel. The molten ash combined chemically with the glowing brickwork, forming a liquid slag which ran down the walls, continually exposing fresh brickwork to the attack. It was clear that could the wall surfaces be kept cold enough to chill the ash particles which came in contact with them a film of solidified slag would form and protect the brickwork from further action. This idea gave rise to attempts to cool the walls by the admission of air at selected points. The result was at best but a mitigation of the trouble, indefensible from the point of view of efficiency and by no means always effective. As no form of air-cooled walls seemed able to solve the problem, the principle of water cooling was adopted, and all modern furnace design turns upon water cooling the walls by some means or other. There are, in this connection, two schools of thought. One would replace some of the brickwork by a metallic water-cooled surface, such as that provided by Murray fin tubes, the remaining brickwork being kept cooler than it would otherwise be by the radiation of "cold" from the cooled surface. The other would maintain the usual refractory surface in its entirety, cooling the furnace walls by means of water tubes embedded in them and, therefore, out of direct contact with the flame.

Such briefly is the position at present. There is not as yet anything which can be called accepted practice, nor does there seem to be much agreement except upon the one fact that no existing refractory material, whether fire-brick, alundum, corundum, or what not, will withstand modern furnace conditions without some form of direct or indirect cooling. The prospects, moreover, of any better material being discovered are still remote. This being so, the question arises more and more insistently as to how far brickwork of any kind is really necessary in a boiler furnace. It is admittedly a source of continual trouble and expense, and to whatever degree these defects may be mitigated by special materials or forms of construction, they are never likely to be reduced to insignificance so long as brickwork constitutes an integral part of the furnace. The suggestion of its complete elimination is likely to arouse protests, but it is nevertheless worthy of unprejudiced consideration. The fact that ever since externally fired boilers have been invented they have been served by furnaces with refractory walls is to be respected, for a practice does not generally become universal without some good reason. But too much weight must not be given to this custom. The early boilermakers sought merely to make some place to hold the fire, and nothing was more natural than to surround it with brick walls, which at need might also serve to support the boiler. For the temperatures then encountered fire-bricks were adequate, especially as the furnaces were small and the proximity of the comparatively cool metal of the boiler helped to prevent any great rise of temperature. The mass of heated brickwork no doubt helped to regularise combustion, but the claim that it is necessary for good combustion is refuted by the hundreds of thousands of Cornish, Lancashire, locomotive, and Scotch marine boilers in which the fires burn perfectly well without the help of any heated brickwork at all. It may be remembered that careful test scarried out under the auspices of the United States Government during the war showed that a higher efficiency was obtainable with the ordinary internally fired Scotch marine boiler than with a corresponding boiler of the marine water-tube type. The reason suggested for the difference was the greater furnace efficiency of the internally fired boiler. These tests confirm, if confirmation be needed, that excellent combustion can be maintained even when the fire and flames are subject to the chilling effect of a water-cooled surface completely surrounding them, and in close proximity to the fire. The radiant heat, moreover, in whatever direction it is emitted, is directly absorbed by the boiler, doing useful work instead of reverberating to and fro between brick walls in a useless and destructive manner. It is not contended, of course, that combustion cannot be interfered with by undue chilling of the flames. The well-known experiment of making a candle smoke by holding a piece of cold iron near it is proof of the contrary, but practical experience of a century with internally fired boilers shows that, with any reasonable design, fears on this score are groundless. Moreover, the larger the furnace the less, proportionally, does the chilling effect become. In view of the facts we have mentioned, there are many engineers who believe that the evolution of the water-tube boiler must proceed in the direction of internal firing, with the elimination of furnace brickwork of any kind. Brickwork is all right and necessary for a metallurgical furnace where the object is to keep the heat in, but the whole duty of a boiler furnace is, on the contrary, to let the heat out. This can obviously be best effected by surrounding the fire by the metal surface of the boiler, a fact realised to the full by the first designers of Lancashire and locomotive boilers. Water-tube boiler practice is indeed tending in the same direction by the development of water-cooled furnace walls, but the tradition of the brick-built furnace still hangs heavily over it. The designer of water-tube boiler plant, in accepting the principle of internal firing, must effect its application for himself. The circular or flat-stayed surfaces of existing internally fired boiler practice are out of the question for him, and his object must be to make the four walls and the roof of his furnace of tubes through all of which the water shall circulate naturally and freely when the boiler is at work. There must be also no joints accessible to the fire and the whole of the tube system must be easy to clean internally and externally. The Wood radiant-heat boiler in its complete form, that is with a tubular "roof," may be cited as a modern example. But even in a modified form, such as that at Kip's Bay, New York, which we illustrate on page 220, it may take much advantage of radiant heat by appropriate design.

Such is, broadly, the boiler problem of the day; more easy to state than to solve. The difficulty lies chiefly in ensuring a regular circulation of the water. The rate of heat transmission will be far greater than is normally attained, and not only the arrangement of the tubes, but their individual diameters and lengths, must be such that the resistance to the circulation of water shall be low enough to permit of a flow sufficient to absorb the heat. Under present conditions the rate of heat transmission in the lowermost row of tubes in a water-tube boiler is as much as 46,000 B.Th.U. per square foot per hour, or more than three times the average for the whole boiler, and far higher rates are certainly practicable with clean water and good circulation. It is likely that well over 100,000 B.Th.U. per square foot per hour is already exceeded in some parts of some boilers without fear of injury to the tubes, so long as the latter are clean internally and adequately supplied with water. Even if we accept existing rates as sufficient and design a boiler so that the whole of the furnace surface is absorbing heat no faster than is now done by the lower tubes of ordinary boilers, the total heating surface required for a given hourly evaporation could be very substantially reduced as compared with existing designs. More heat, too, could be liberated in a given furnace volume so that furnaces themselves would be proportionally smaller. Indeed, once the problem of efficient circulation is solved there would seem to be no reason why to the many advantages of the water-tube boiler should not be added those arising from internal firing, among which the elimination of brickwork troubles is by no means the least.

Obituary.

ALEXANDER SIEMENS.

A FIGURE, once very prominent in the domain of electrical engineering, and at scientific gatherings in the Metropolis, has been removed by the death of Mr. Alexander Siemens, which took place at Milford-on-Sea, on Thursday, February 16th. Since an early period of the war, when circumstances arose which, as we shall presently show, caused his retirement from a prominent position, Mr. Siemens who, at one time was to be seen constantly and regularly at the meetings of the various technical and scientific societies with which he was associated, had led a life of almost complete seclusion.

Alexander Siemens, who was the son of Gustav Siemens, was born in Hanover, on January 22nd, 1847. He had, therefore just completed his eighty-first year at the time of his death. He came of a family which regarded the Kings of England as their sovereigns, and had it not been for the Salic Law, which precluded Queen Victoria from reigning over his native state, Alexander would have been a subject of the English throne. As it was, he, technically, became a Prussian in 1866 when Hanover was annexed by Prussia. Actually, however, there is no doubt that in sympathy and sentiment he was pro-British, and though, it is true, he had to fight for Prussia when she went to war with France, he was very soon afterwards to become a British subject. He was one of a line of distinguished men, men who made their mark. We need only mention Ernst Werner von Siemens, one of the foremost electrical engineers of his time, and one of the founders of the firm of Siemens and Halske, Sir Charles Siemens, and, finally, Sir William Siemens, whose name is so well known in connection with steel manufacture. It was on the invitation of the latter that young Alexander, then twenty years old, came to London in 1867 to enter the works—then recently founded—of Siemens Brothers at Woolwich. There, he was, at first, engaged in telegraph engineering and subsequently in the running of telegraph lines and the laying of cables in Persia and Russia.

Being liable for military service, he had to return to Germany in 1868, but was not, at first, accepted by the Army on account of his eyesight. However, on the outbreak of the Franco-Prussian War, he was called up and drafted into an infantry regiment. He was wounded at the battle of Beaume-la-Rolande, was present at the Siege of Metz, and was granted the Iron Cross, a distinction much more rarely conferred and more highly prized then than in later times.

In October, 1871, as soon as he was discharged from the Army, he came back to this country, and here, with short intervals, he continued to live for the remainder of his life. Very soon he took steps to be released from German citizenship and to become a naturalised Englishman. He succeeded, as regards the former, in March, 1878, and, as regards the latter, in the following August.

On his return to England the first few years were spent not, apparently, so much in telegraph work, as in assisting Sir William Siemens in developing the

regenerative gas furnaces with which the latter's name is so intimately associated. Later, he was again engaged in cable laying, being employed in the cable ship "Faraday," for a couple of years or so, when she was at work on the North Atlantic Coast. Thereafter he erected furnaces to Sir William's designs in the United States and in Canada. It was shortly after his return to this country that he became naturalised, as related above.

Just about that time electric arc lighting was coming into prominence. The Paris Exhibition had shown the world what a wonderful thing this new illuminant was, and electric machinery manufactures vied with one another in producing apparatus for the purpose. In 1879 Alexander was made manager of the electric light department of the Woolwich works, and he carried out, in addition to a good deal of demonstrational work—some of it for street lighting—several notable installations, among which were those in the reading-room at the British Museum and in the Albert Hall. He also laid down the electric lighting plant at Godalming, in Surrey, which was, we believe, the first town in England to have an electric light supply.

Electric lighting at that time was very different in character from what it is now. The Siemens arc lamps of the period each required a separate machine to drive them. But developments were rapid, and in those developments Alexander Siemens and his firm played an important part. It may be said of him, in fact, that, apart from telegraph engineering, which was well established before his time, his professional career covered the whole period of electrical commercial progress—if we may use such an expression to differentiate it from laboratory achievement. How rapid was the advance, even at first, was well shown by the Electrical Exhibition at the Crystal Palace early in 1882, at which incandescent lamps were much in evidence. The Siemens machines and lamps then shown attracted a great deal of attention, and in view of the position he held, it is reasonable to assume that Alexander Siemens played a leading part in their production.

In the following year—that is, 1883—Sir William Siemens died, and Alexander's responsibilities at the Woolwich works increased. Finally, he assumed full direction. Thereafter his history is so intimately bound up with the fortunes of the firm that it is practically impossible to separate one from the other. In 1887 he was made a director of the company, a position which he continued to occupy for thirty-one years. On his retirement he was presented with a clock and an address containing the names of over eleven hundred of the employees of the firm.

In 1883 Mr. Siemens, in collaboration with Dr. Edward Hopkinson, delivered, before the Society of Arts, a lecture which, though at the time it dealt with most serious things, provides nowadays some amusing reading. It was entitled "The Transmission of Power by Electricity, and the Portrush Railway." The lecture was illustrated by experiments. First, a pump was shown drawing water from a tank, forcing it through a tube and returning it to the tank. "The pump," we learn, "was worked by a strap from a Siemens' machine, used as a motor, and the current was obtained from a somewhat larger machine, which is ordinarily used for lighting the hall of the Society of Arts, but which, for the present, has been taken for the purpose of experiment." The pump was then disconnected, and replaced by a very small motor working a sewing machine. It was important, the paper stated, to observe that the same generator was used in both cases, and that neither its speed nor any other of its conditions had been altered, excepting only the pull on the driving strap; but that, in the case of the pump, probably about 5-horse power of useful work was being done, while in the case of the sewing machine, perhaps $^1/_{50}$-horse power. Then, while the sewing machine was still at work, the forty incandescent lamps required for lighting the room were connected with the generator. The sewing machine still performed its $^1/_{50}$-horse power of work, while from the same generator and the same leading wires about 5-horse power was employed in lighting the room. "These illustrations," added the lecturers, "would be sufficient to show, in the first place, that when once we have electrical mains of sufficient capacity carried from central stations to our houses, how simple a matter it will be to combine lighting with domestic operations, and even the larger operations required for purposes of trade; and, in the second place, that each motor of a series placed in parallel circuit, performs the work required of it independently of all the others, and independently of the generating machine, provided only that the generator is capable of producing the power it is called upon to furnish."

Then, when dealing with the Portrush Railway, it was stated that the resistance of a mile of track, including the return by earth and the ground rails, was 0·23 ohms. "If calculated from the section of the iron," remark the authors, "it would be 0·15 ohms, the difference being accounted for by the resistance of the copper loops, and occasional imperfect contacts. The electro-motive force at which the conductor is maintained is about 225 volts, which is well within the limit of perfect safety assigned by Sir William Thomson and Dr. Siemens. At the same time, the shock received on touching the iron is sufficient to be unpleasant, and hence is some protection against the conductor being tampered with." In later years, if his thoughts ever went back to penning that last sentence, Mr. Siemens must have laughed heartily.

Mr. Siemens became an associate of the Institution of Electrical Engineers—then the Society of Telegraph Engineers—as long ago as 1872, and was promoted to full membership in 1880. He had the somewhat rare distinction of twice acting as its president, first in 1894 and again in 1904. He entered the Institution of Civil Engineers as a student, became an Associate Member in 1873 and a full Member in 1890. Twenty years later—in November, 1910—he was chosen President, and thus had the honour of having been President of two of our foremost engineering societies.

Sometimes, though rarely, a presidential address gives an insight into the character of the man who delivers it. It was so with the late Mr. Michael Longridge's address before the "Mechanicals"; it was so with Mr. Siemens' address. It showed him to be a man of wide reading, and deep thought. It did not contain long lists of figures nor did it trace the progress over a series of years of some branch of his profession or some work or series of works. Instead, it touched lightly on a multiplicity of subjects, and had for its central theme the consideration of how much the engineering profession had had to do with bringing about our present state of civilisation. In order rightly to appreciate the share it had had, "a comparison should," he urged, "be made between the conditions prevailing, say, in the Greek States during the fifth and fourth century before Christ and those existing now in the twentieth century after Christ." He went on to remind his listeners that that was the age of Themistocles, Aristides and Pericles, the statesmen; of Æschylus, Sophocles, Euripides, and Aristophenes, the dramatists; of Phidias, Scopas, and Praxiteles, the sculptors; of Apollodorus, Zeuxis, and Apelles, the painters; of Ictinus, the chief designer of the Parthenon, and Dinocrates, who rebuilt the temple of Diana at Ephesus and laid out the city of Alexandria, the architects; of Herodatus, Thucydides and Xenophon, the historians; of Socrates, Plato and Aristotle, the philosophers. "Can we say," he asked, "that there have been many since that time who are worthy to be mentioned as equals of the men I have just named? The fact alone that we use the adjective 'classical' to indicate perfection in literature and art shows what a standard had been attained more than 2000 years ago, and in many respects we feel down to the present time the direct influence of Greek and Roman learning."

We cannot spare space to follow him through his description of the ups and downs of the intervening period; it must suffice to summarise his conclusions. They were that though in literature, art and philosophy, we could not boast of being greatly superior to the ancients, as far as engineering problems were concerned, we had enormously advanced, thanks to the practical application of scientific theories. We might, he said, sum up the difference by claiming that the progress made was due principally:—(1) To the improvement of the means of communication; and (2) to the saving of manual labour by the introduction of mechanical power. Those main features had caused a general lowering of the cost of "obtainables." Engineers might, he concluded, claim that their endeavours had materially furthered the great modern object of conferring the greatest good on the greatest number, "but in continuing our efforts we must never forget that in these strenuous times more than ever the admonition of the Preacher obtains: 'Whatsoever thy hand findeth to do, do it with thy might.'"

As regards work outside his immediate profession, Mr. Siemens, in 1897, formed one of the Committee appointed to inquire into the desirability of founding the National Physical Laboratory, on the Governing Committee of which Institution he, subsequently, had a place.

The beginning of the war found Alexander Siemens occupying a post of great distinction—that of Secretary to the Royal Institution. It was a position which had always been held by men of high standing. He, himself, had followed Sir William Crookes, who had succeeded Sir Frederick Bramwell. Mr. Siemens had always been an honoured member of the Institution and had delivered Friday Evening Discourses on four separate occasions. That, in itself, was an honour, for the Discourses are always entrusted to men of especial note in their professions or walks of life. The Secretary, for the time being, has a great deal to do with the management of the Institution's affairs, and, when the war came, the secretaryship was in the hands of a man who, though he had been a naturalised Englishman for nearly forty years, had previously belonged to a nation with which we were waging war, and who had himself fought against France. The full circumstances were not, we believe, ever made public, but evidently Siemens must have felt so uncomfortable in his position that he found it no longer tenable, and he resigned. In a letter to the Institution, which was published in *The Times* of February 2nd, 1915, and which was most pathetic in its wording, he avowed, in effect, that he had always considered himself as owing allegiance to the British crown, and expressed his detestation of the actions of our enemies.

To all intents and purposes, that ended the public career of Alexander Siemens. A man, getting on in years and feeling, doubtless, embittered at the turn of events when he was conscious only of having done his duty, he retired into the country and was rarely seen or heard of thereafter. It must be said, however, that of those who knew him best, there was not one who doubted his absolute loyalty and integrity.

Literature.

Vertical Shaft Sinking. By E. O. FORSTER BROWN. London: Benn Brothers, Ltd. 1927. Price 52s. 6d.

IT is practically impossible in a brief review such as the present to do more than merely touch upon the main features of this outstanding treatise. The work as a whole is of sterling value, and the arrangement of the subject matter, the excellent detailed diagrams, and the mass of information presented, make the publication the foremost of any which have appeared on this important branch of mining in recent years. The book is divided into four parts. Part I. deals with the general principles, appliances, &c., of ordinary shaft sinking. The statement on page 26 that "it is important not to bore on or too close to the actual site of the shaft," is one with which not all mining engineers would agree, as there is solution to the difficulty anticipated. In some recent cases such a hole would have been invaluable, especially where the shaft has met with a fault.

Part II., which consists of a careful analysis of the various special methods adopted and practised successfully in this country and abroad for sinking through ground of exceptionally difficult character, is of great value, and the author has not wasted space by describing obsolete and valueless methods. Chapter III. deals with Piling, Drop Shaft and Caisson Methods, and, in the main, it emphasises the ingenuity and skill of the British mining engineer. Chapters IV. and V. are teeming with interest, and the reader is led step by step through the cementation process and the freezing process in a manner which proves beyond doubt their suitability under certain conditions. Many freezing contractors give a guarantee of time and success in advance, which in some cases may give the system an advantage and make it prove more attractive to a company than the drop shaft, caisson or cementation methods.

In Part III. the experience and thoroughness of the author are evidenced in the vivid manner with which he deals with Excavations, Shaft Linings, Shaft Transport and Equipment, Drainage, Lighting, Ventilation and Labour. Invaluable tables, comparative methods and statistics are given. We may especially refer all interested in drilling operations to pages 190–197, which deal with drills, heat treatment of steel, drill steel consumption, &c.

Part IV. is highly instructive, dealing as it does very ably with Economics and General Considerations. The introduction of these subjects constitutes a progressive step in this type of publication. The cost of sinking varies considerably, and, broadly speaking, depends largely upon certain conditions. The author gives comparative figures showing the ratio of shaft yardage to average tons of daily output for Great Britain in 1924, for the Rand mines of the Central Mining Investment Corporation, Ltd., for 1924, and for a few American mines. The comparison is not as complete as it might be, owing to the limited number of cases in which detailed statistical information of this character appears to be kept. The paragraphs dealing with labour consumption are to be commended.

Table XX. outlines the Percentage of Time Spent on Various Operations during Shaft Sinking in specific cases. Progress graphs of dry sinking (Yorkshire), wet and partly dry (Nottingham), partly wet (cemented), and partly dry (Nottingham), and a Dutch freezing sinking are shown. On the whole, the average speed of sinking and lining British shafts in dry ground compares very favourably with that attained on the Rand, where records have been made recently.

Summarising the essentials for successful shaft sinking, the author stresses the importance of an ample margin of funds, power and strength in the appliances used, the employment of proved and reliable appliances, a suitable complement of highly skilled and specialised labour, coupled with experienced, efficient and energetic management. This admirable treatise should attract the attention of all connected with colliery sinkings, exploitation and development work.

BOOKS RECEIVED.

Electrical Engineering Economics. By D. J. Bolton. London: Chapman and Hall, Ltd., 11, Henrietta-street, W.C. 2. Price 21s. net.

Specification, 1928. Edited by F. Chatterton, F:R.I.B.A. London: The Architectural Press, 9, Queen Anne's Gate, S.W. 1. Price 10s. 6d. net.

Cast Iron in the Light of Recent Research. Third edition. By W. H. Hatfield, D. Met. London: Charles Griffin and Co., Ltd., 42, Drury-lane, W.C. 2. Price 16s. net.

CORRECTION.—In our last issue the price of Mr. Palmer's "Wireless Principles and Practice" was given as 10s. It should have been 18s. net.

The West Templeton Paper Mills, Canada.

ONE important industry which has been made possible in Eastern Canada through the immense power development project of the Gatineau Power Company on the Gatineau River, in the province of Quebec, is the big newsprint enterprise of the International Paper Company at West Templeton, on the Ottawa River. The mills, together with the various departments for ground wood, sulphite and pulp and paper, are among the largest in the world. They have a daily capacity of 600 tons of paper and are so arranged that that output can be doubled if required. The construction work was carried out by the Fraser Brace Engineering Company, of Montreal.

The initial installation consists of four of the most modern paper machines on the market to-day, each with a daily capacity of 150 tons. The width of the paper passing over the rolls is 256in., while the machines operate at the high speed of 1000ft. per minute. The construction of the mills furnished employment to nearly 2000 people. Around the plant has sprung up a small town, which has been named Gatineau, and which is rapidly assuming the appearance of a thriving community, with schools, churches, public library, community hall and several commercial establishments. The mills employ about 1500 men. In addition, hundreds are engaged in the bush, sending down the logs from the company's timber reserves, which cover a vast region on the watershed of the Gatineau River.

The rapidity with which the newsprint plant was built is an outstanding achievement, even in these days of fast construction. Excavation work was started on November 18th, 1925, and construction work on January 13th, 1926. A little over a year later, March 31st, 1927, the sulphite mill began production. Five days later the ground wood mill was put into operation. The first machine began making paper for shipment on April 14th, 1927, just seventeen months after excavation work was begun. The second machine turned out paper for the first time on May 19th, and was followed by the third and fourth machines on June 28th and August 19th respectively.

The mills cover an area of 470,000 square feet. They required 200,000 cubic yards of excavation, 65,000 yards of concrete, 8000 tons of structural steel, and 6,000,000, bricks. There are several miles of water pipe, and steam and air lines. The capacity of the process water system is over 28,000,000 gallons of water per day, and the drinking water plant has a capacity of 360,000 gallons of filtered water a day for mill and town use. Each year over 6500 tons of limestone will be used, as well as 5100 tons of sulphur.

Owing to the nature of the soil which fronts the river for about three-quarters of a mile and runs back to the Canadian Pacific Railway, the construction company erecting the plant was confronted with an early difficulty. This was due to the spongy nature of the surface earth, which made it necessary to change the original plans, and involved an expenditure of many thousands of dollars over and above the estimated cost. Massive piles had to be sunk to receive the concrete foundation for the big newsprint mill before construction could be gone ahead with.

An outstanding feature of the plant is that every application of power in it is electric. The machines are electrically driven with direct drive. The electric power required to operate the plant is supplied from the two big developments of the Gatineau Power Company at Farmers Rapids and Chelsea, on the Gatineau River, a few miles away. At the present time, all steam is generated by electricity, but the power will be gradually withdrawn and coal used, when the Gatineau Power Company begins to deliver power to the Ontario Hydro-Electric Power Commission. The contract entered into with the Ontario Government a year ago calls for a supply in the neighbourhood of 260,000 horse-power. Plans have been made at the newsprint plant for the installation of a modern steam boiler plant, using pea coal. It will be built in such a manner as to provide for its extension as the need of additional power develops.

The Federal Government has dredged a channel in front of the dock of the mill, thus permitting water shipment of paper to New York and other eastern points. The wood supply for the mill goes in by water. There is an island opposite the mill in the Ottawa River, forming a natural and safe holding ground for the wood. On the Gatineau River the company owns over 7000 square miles of timber lands. It is estimated that these woodlands contain a perpetual supply of wood for the mill. In this area the company has put into effect the most complete and comprehensive fire protection system which is known to modern forestry practice. Observation towers are strategically situated and interconnected by telephone lines. Throughout the woods there are caches for pumps and engines and for petrol and oil to run them; hose and other fire-fighting equipment are placed at focal points; aeroplane service is used for reconnaissance, and men and equipment can be quickly concentrated at points of danger.

The construction of the mill at West Templeton is part of the comprehensive plan which the International Paper Company has laid out for the development of the power and wood resources of the Gatineau River and district. The Gatineau Power Company, which controls and operates the power plants on the Gatineau River, is a subsidiary of the International Paper Company. In addition to the power plants at Chelsea and Farmers Rapids, the company has a third hydro-electric plant under construction at Paugan, 32 miles north of the city of Ottawa, and 25 miles above the other two plants. The Paugan plant will probably be in operation about the end of August this year. With a designed capacity of 272,000 horse-power, it will be the largest of the three, Chelsea and Farmers Rapids having respectively designed capacities of 170,000 and 120,000 horse-power. The large quantity of power which the Gatineau Power Company has available for sale is destined to make the Ottawa and Gatineau district one of the great industrial centres of North America.

From the illustrations given on page 212 some idea of the proportions of the mill may be obtained.

Waste Heat Recovery.

THE paper which Major W. Gregson presented before the Institution of Mechanical Engineers on Friday evening of last week, February 17th, was divided into two parts of approximately equal length. In the first portion the author dealt with the theoretical and arithmetical aspects of waste heat recovery in steel works, in gasworks and on ships fitted with oil engines. In the second portion he dealt with the practical side of waste heat recovery in the same three connections.

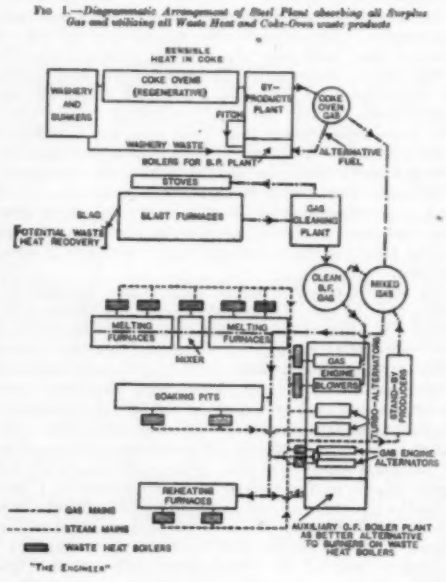
The author's discussion of the theoretical aspects of waste heat recovery in steel works was based on the diagram reproduced in Fig. 1. He claimed that by proper organisation and by utilisation of all the surplus industrial gas, including waste heat recovery, it was easy to show that the works could depend entirely for the whole of its metallurgical gas, process steam and power on the coal supplied to the coke ovens, namely, about 32 cwt. per ton of pig iron. Dealing with the individual points affording opportunity for waste heat recovery in a steel works, Major Gregson remarked that the coke ovens provided such a source only if the ovens were of the non-regenerative type. The recovery of the waste heat from the hot coke and the blast-furnace slag had, he said, made practically no progress, because, apparently, of complications in operation and the considerable capital expenditure involved. In gasworks practice, however, the dry quenching of coke by means of inert gases had made considerable progress, and should be applicable, he suggested, to coke oven coke. Consideration was also given to the recovery of waste heat from the exhaust of gas engine driven blowers, and from the flue gases from the steel and mill furnaces.

Dealing with gasworks, the author remarked that waste heat was available for steam-raising purposes from the retort settings, from water gas plants, and from the hot coke. In addition to the increased cost of fuel and of labour, the gas engineer had to consider a third factor, the price of coke breeze. Previously, that product had been unsaleable, and was useless except for firing the gaswork's own boilers. Developments had occurred recently, however, in the use of coke breeze for fuel-fired boilers, and as a result of the opening up of a potential market for the breeze, the gas engineer had adopted waste heat boilers instead of using the coke breeze for firing his boilers.

Turning to marine oil engines, Major Gregson remarked that waste heat recovery in that field had been given close attention, first in order to increase the overall efficiency of an already highly efficient prime mover, and, secondly, to meet the demands for auxiliary power and heating services required on shipboard. The potentialities of waste heat recovery were investigated for a typical four-cycle and for a typical two-cycle engine.

The second portion of the paper is reprinted in full below.

FIG. 1.—*Diagrammatic Arrangement of Steel Plant absorbing all Surplus Gas and utilising all Waste Heat and Coke-Oven waste products*



WASTE HEAT RECOVERY PRACTICE.

Apart from early practice on direct-fired forge and puddling furnaces, waste heat recovery was first effectively attempted on a considerable scale by water-tube boilers, the success of these boilers as rapid heat transmitters when fired with solid and gaseous fuels naturally leading to their adoption for extracting the sensible heat from furnace gases, &c. In particular, numbers of steel works and cement works were equipped with these boilers prior to the war.

The author first commenced his waste heat recovery investigations on pre-war water-tube waste heat boilers, and as those investigations proceeded, one important fact became clear, namely, the difference between the heat absorption problems involved in "high-grade" waste heat recovery, where conditions approximated to those in solid-fuel firing practice, and in the recovery of waste heat from low-grade gases, such as occur in regenerative furnace practice.

In the first instance, the proportion of heat absorbed by radiation is high, hence the immediate success of the water-tube boiler, which is pre-eminently a radiant heat absorber. In fact, under solid fuel firing conditions, some 70 per cent. of its total evaporation occurs through radiation and in the rows of tubes facing and contiguous to the fire. Beyond this zone, the evaporation per unit of heating surface falls rapidly and in general practice the economiser or air heater or both, if employed, deal with the "tail" of the gases. The fundamental difference in the case of low-grade gases can be clearly understood from Stefan's law, which states that heat absorption by radiation varies as the fourth power of the absolute temperature of the heating medium. Obviously, therefore, a standard fuel-fired design of water-tube boiler applied to a low-grade heat absorption problem suffers a "delayed action" process, owing to the fact that the radiant heat absorbing properties of the first section of the heating surface are in operation far below rating; that is to say, the heat transference depends mainly on conducted heat. The result is that for efficient extraction of heat from the waste gases the economiser has too much to do, and hence there is a surplus of hot water.

When the radiant heating effect is small, all attention must be focussed on obtaining the best possible heat interchange results by actual conduction; that is, intimate molecular contact between the gas particles and the walls of the heating surface is called for. To enable the water-tube boiler to cope with these altered circumstances when dealing with low-grade gases, it was therefore necessary to place the tubes closer together, particularly towards

FIG. 2.—*Waste-Heat Boiler on Talbot Steel Furnace.* (*Spencer-Bonecourt.*)

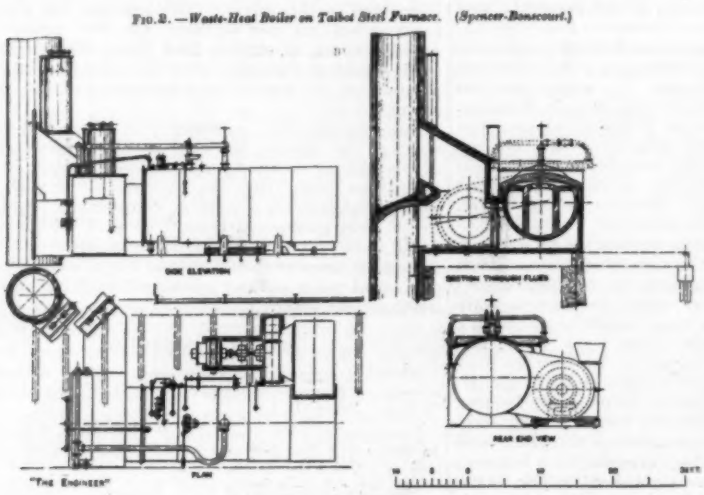
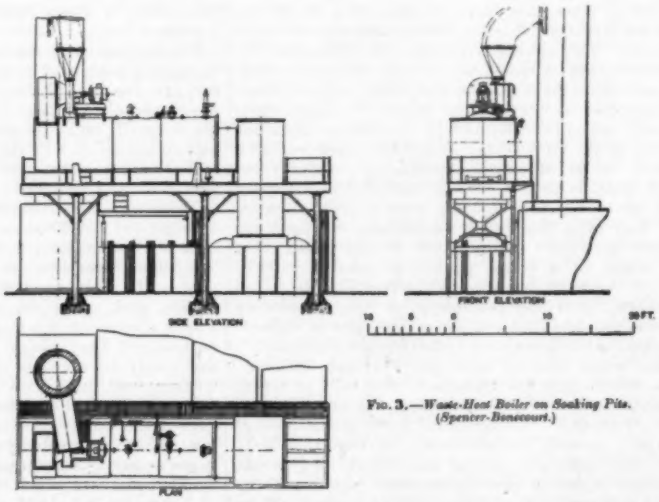


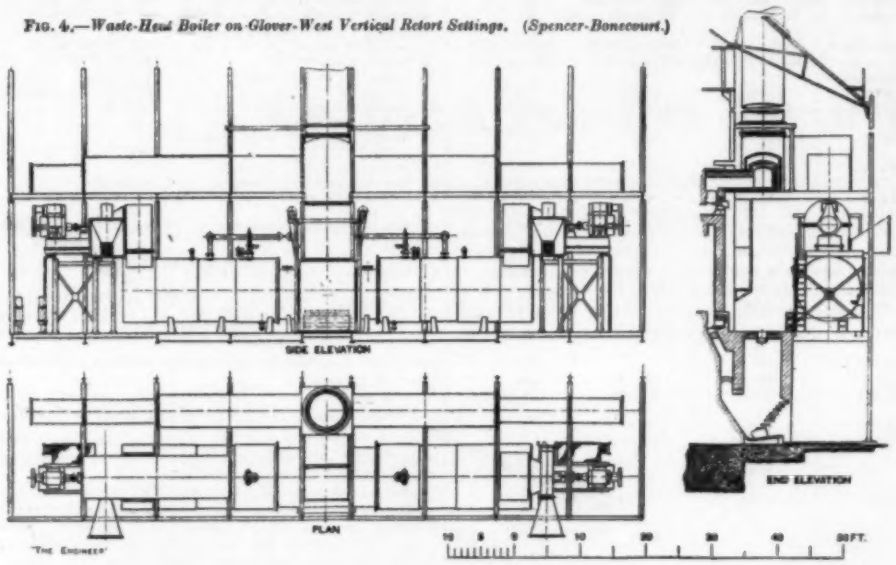
FIG. 3.—*Waste-Heat Boiler on Soaking Pits.* (*Spencer-Bonecourt.*)



the back of the boiler, and so to break up the gas stream and enforce close contact between the gas and the tubes. The disadvantages of this arrangement were two-fold; it involved a heavy increase of draught drop through the boiler and it interfered with tube cleaning on the gas side of the heating surface. The first of these disadvantages unfortunately led to further trouble, which gradually developed when the boiler had been operating for some time. This was due to air infiltration through the casing, adding to the volume to be handled by the induced draught equipment and also cooling the gases *en route* through the boiler.

The great advantage possessed by the fire-tube boiler in dealing with waste heat problems involving low-temperature gases is readily realised, and a period of detailed investigation on locomotive boilers was of assistance to the author.

FIG. 4.—*Waste-Heat Boiler on Glover-West Vertical Retort Settings.* (*Spencer-Bonecourt.*)



phenomenon of turbulent flow which occurs when certain gas speeds are reached or exceeded.

Summing up, the water-tube boiler has a definite field for waste heat recovery practice, when the gases approach fuel-firing conditions, and this field can be extended by suitably disposing the tubes for better contact heating effects, provided moderate draughts are employed.

For low-grade gases, particularly from regenerative furnaces, the fire-tube boiler has a practically unchallenged field, owing to its suitability for high draught drops, coupled with high heat transfer coefficients.

Practical examples of waste heat recovery plant will be confined to fire-tube practice, as this represents the work with which the author has been most closely associated during recent years. It should be made clear, however, that he does not in any way condemn the water-tube boiler when applied to waste heat recovery, because such an attitude would be indefensible.

The types of fire-tube boiler unit suitable for both steel works and gasworks practice are practically identical, and typical installations are shown in Figs. 2, 3, 4, 5 and 6. The following details need attention in considering individual problems:—

(*a*) There is a greater variation in rates of gas flow in steel furnace plant, particularly in the case of melting furnaces, than in gasworks practice, except in water gas plants, which are mentioned below.

(*b*) As a rule, tube-cleaning arrangements on the gas side of the heating surface have to be more effective in steel works plants owing to the greater difficulties associated with the deposits, due to the practice of hydrocarbons in the producer gas, coal being the fuel instead of coke as in a gasworks, and fine dust from the bath and linings of melting furnaces, which tends to congeal.

(*c*) Electrical gear for fan operation, &c., needs more protection in gasworks installations, owing to the presence of finely divided coke dust in the atmosphere.

(*d*) Close attention must be paid to such details as flue lay-outs and proportions, the effective insulation of intake flues, suitable damper gear, and the correct proportioning of induced draught equipment. The last is particularly important where very accurate adjustment is required on the furnaces or retorts. Many waste heat recovery schemes are spoiled by inattention to details of this sort.

(*e*) On water gas and similar plant, such as complete carbonisation units, operating on a "blow" and "run" sequence, the boiler operates under pressure, its resistance being superimposed on the plant circuit, and success in these cases depends largely on burning adequately the products of the "blow" period. Although easily burnt when liberated directly to the atmosphere, these are far less combustible when confined in a flue, as the carbon monoxide often passes in a stream line through the boiler unburnt. The inlet chambers of such boilers must be of special design, with auxiliary secondary air blast and mixing arrangements to effect complete combustion at the correct period. Again, the intermittent nature of the steam-making period and the varied steam demand of the plant and its auxiliaries calls for adequate water and steam space, otherwise cyclic priming and heavy variations in steam pressure occur.

Waste heat boilers on internal combustion engines have one feature in common with the last-mentioned class of boiler, *i.e.*, they operate under pressure, in this instance superimposed on the engine circuit. Owing, however, to the rapid cooling of the gases passing through the boiler, with a resultant rapid fall in velocity, the back pressure set up by a suitably designed boiler is invariably less than occurs in the standard silencer. This rapid reduction in gas volume makes the waste heat boiler a very effective substitute for the silencer.

As a general rule, comparatively heavy back pressures are permissible in internal combustion engines. A perusal of the reports of the Marine Oil Engine Trials Committee demonstrates this point. Hence a closely spaced water-tube or thimble-tube boiler can, under these conditions of service, be very effective, as good contact heating is not prejudiced by high resistance to gas flows.

The question of auxiliary firing occasionally arises in connection with waste heat recovery schemes. With a fuel fired design of boiler, this is readily arranged for the

FIG. 5.—*Waste-Heat Boiler on Woodall-Duckham Vertical Retorts.* (*Spencer-Bonecourt.*)

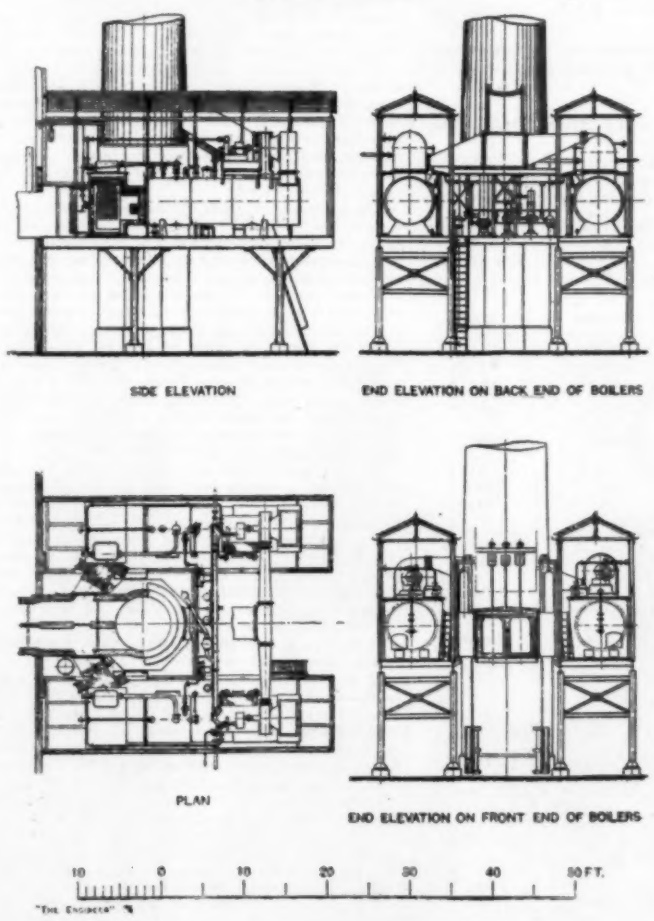
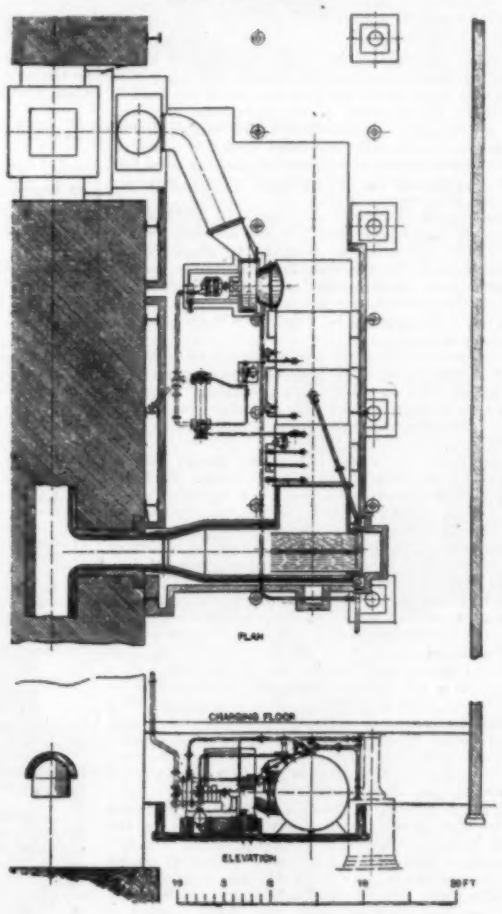

SIDE ELEVATION
END ELEVATION ON BACK END OF BOILERS
PLAN
END ELEVATION ON FRONT END OF BOILERS
10 5 0 10 20 30 40 50 FT.
"THE ENGINEER"

FIG. 6.—*Waste-Heat Boiler on Horizontal Retort Settings.* (*Spencer-Bonecourt.*)



As already stated, where the waste gas conditions approximate to fuel firing practice, the water-tube boiler is an extremely effective waste heat boiler. The only advantages which the fire-tube boiler can claim under such conditions are its smaller size and its ability to stand high draught drops without air infiltration. Where space is not a serious factor, the water-tube boiler can be of suitable dimensions to allow a large heating surface and a low draught drop, thereby discounting the second of the

full rating on a heating surface basis, and even on a boiler designed purely for waste heat recovery, alternative firing, producing an evaporation figure equivalent to the output on waste heat, can readily be applied. Such a boiler, however, is inherently unsuited for heavy fuel firing with correspondingly high increases in evaporation per unit of heating surface, on account of the ease with which it could be overforced. Undoubtedly, the simplest and best arrangement, especially in a large works, is to install an auxiliary boiler or set of boilers designed for solid fuel firing, and by keeping the two sections entirely separate to get the best all-round results.

On certain types of motor ship there is nowadays a tendency to fit one boiler only for sea and port work, especially where steam is not essential to main engine-room requirements. As it is only necessary to reproduce normal waste heat evaporations when such boilers are fired with oil, the problem becomes a simple one.

The marine field appears to subdivide itself into the following three groups :—

(1) *Tankers.*—Small steam requirements at sea, but heavy port steaming, owing to the cargo pumps and tank heating. These services require comparatively large oil-fired boilers, so that for sea services a straight waste heat boiler with perhaps one of the other boilers under light firing is sufficent.

(2) *Passenger Ships.*—Steam is required almost entirely for heating services as all power is electrical. Either a combination boiler meets the case or a straight waste heat unit with a small donkey boiler as standby and for port services. The latter arrangement is very convenient, as it enables the waste heat boiler to be out of action in port when the engines are being adjusted or overhauled.

(3) *Cargo Ships.*—The sea-going conditions in this case are similar to those in (1), and requirements vary widely. On ships making frequent calls, the all-electric deck equipment with its high efficiency compensates for higher capital cost, while on ships making long trips without intermittent calls, present practice appears still to call for steam deck machinery. With all-electric auxiliaries, the best use for the waste heat steam would appear to be to operate a steam-driven generator in parallel with the oil engine driven generator. Heating steam could then be "bled" from the steam generator, or the exhaust used for heating purposes. Alternatively, the steam could be concentrated on the supercharger, where fitted.

Mention may be made of the possibilities of getting a return from the cylinder jackets as an adjunct to the waste heat boilers. The high efficiency of the "Still" cycle depends on this item. With the ordinary oil engine the water leaving the jackets is of little use, on account of the hot-well supply already available for the boiler from the condenser and the fact that sea water cooling is common practice within the present temperature limits which are worked to.

Typical Performance Figures.

Table I. sets forth some test figures obtained by the actual operating staff under ordinary working conditions on various types of gas retort settings. One item gives the calculated results compared with actual results, and it will be noticed that the discrepancies are very small. Every care was taken in obtaining the readings, but in view of the difficulties in eliminating small errors, the Table shows that the general trend of such errors is to balance each other in the complete sequence of factors which determine the result. Table II. gives test figures on typical steel melting furnaces, and Table III. refers to a motor ship. The author acknowledges his indebtedness to the engineers concerned for permitting him to publish these results.

Table I.—*Test Results from Waste Heat Recovery Plant on Gas Retort Settings.*

	Vertical retort settings.			Horizontal retort settings.		
1. Gasworks	Nine Elms (Gas Light and Coke Company)	Oldbury	Hull (British Gas Light Company)	Beckton (Gas Light and Coke Company)	Bromley (Gas Light and Coke Company)	Croydon
2. Type of retort	Glover-West	Glover-West	Woodall-Duckham, with regeneration	Drakes, with regeneration	Gibbons, with regeneration	Drakes, with regeneration
3. Fuel per hour, lb of coke	7,060	590	880	4,000	6,300	1,075
4. Calorific value of fuel (lower) B.Th.U. per lb.	12,000	12,000	12,000	12,000	12,000	12,000
5. Temperature of gases at boiler inlet = T_1	800° C.	850° C.	582° C.	655° C.	699° C.	467° C.
6. Temperature of gases at boiler outlet = T_2	230° C.	195° C.	228° C.	243° C.	222° C.	199° C.
7. CO_2 content in waste gases, per cent.	12·4	14·4	12·5	14·0	16·3	9·8
8. Equivalent excess air, per cent.	113	75	110	80	40	200
9. Number of boilers under test	2*	1	1†	2	4	1
10. Total heating surface, sq. ft.	6,800	1,420	1,220	6,880	8,800	1,850
11. Duration of test	16 hours	24 hours‡	72 hours	16 hours	12 hours	28 days
12. Average steam pressure, lb. per sq. in.	115	85	99	155	67½	100
13. Saturated steam temperature = T_s	374° F. (175° C.)	328° F. (165° C.)	338° F (170° C.)	368° F. (187° C.)	314° F. (157° F.)	338° F. (170° C.)
14. Superheat	95° F.	247° F.	106° F.	127° F.	—	92° F.
15. Feed temperature	90° F.	52° F.	199° F.	160° F.	130° F.	134° F.
16. Evaporation per hour, actual, lb.	30,000	2,390	3,340	13,250	22,400	3,213
17. Evaporation factor	1·25	1·37	1·11	1·17	1·12	1·17
18. Evaporation per hour, from and at 212° F., lb.	37,500	3,275	3,710	13,250	22,400	3,213
19. Evaporation per hour, per lb. of fuel, lb.	5·3	5·55	4·21	3·4	3·55	2·98
20. Evaporation per hour, per sq. ft. of heating surface, lb.	5·45	2·30	3·04	1·93	2·54	1·74
21. Total fan horse-power	134	3	§	‖	100	19½
22. Steam equivalent of fan power, lb.	2,948	105	§	‖	2,500	468
23. (22), percentage of total steam	7·8	3·2	—	—	11¼	14½
24. Extraction efficiency $= \frac{T_1-T_2}{T_1-T_s} \times 100$ per cent	91	95·5	86	88	88	90
25. Calculated evaporation per lb. fuel, assuming 86 per cent. producer eff., lb.	5·4	5·6	4·15	3·4	2·55	2·95
26. Percentage difference between (19) and (25)	1·9	0·9	1·4	—	—	1·0
27. Method of measuring evaporation	Tank	Tank	Water meter	Tank and steam meter	Tank	Water meter

* This installation consists of three boilers, two working and one standby.
† One of two boilers, each taking the waste gases from half the installation of settings.
‡ Gas plant operating at approximately half rated output when test was made.
§ Fan driven by geared turbine and all exhaust steam utilised by feed heater to raise initial feed to 199° F.
‖ Fans driven by geared turbines and all exhaust utilised by feed heater to raise initial feed to 160° F.

Table II.—*Test Results from Waste Heat Recovery Plant on Steel-melting Furnaces.*

1. Works	Frodingham Iron and Steel Company	Partington Steel and Iron Company
2. Type of furnaces under test	Two Talbot furnaces	55-60-ton open-hearth furnace
3. Total weekly capacity, tons	2,600	600
4. Total steel per hour, tons	16·2	4·6
5. Coal in producers per hour, cwt.	67	27½
6. Calorific value of coal, B.Th.U. per lb.	12,600	12,000
7. Coal per ton of steel, cwt.	4·125	6
8. Duration of test	16 hours	1 week
9. Total heating surface, sq. ft.	13,630	4,175
10. Mean inlet temperature = T_1	670° C.	540° C.
11. Mean outlet temperature = T_2	212° C.	220° C.
12. Mean CO_2, per cent.	9·4	8·5
13. Excess air, per cent.	150	188
14. Steam pressure, lb. per sq. inch	98	110
15. Steam temperature = T_s	337° F. (170° C.)	344° F. (173° C.)
16. Feed temperature	200° F.	125° F.
17. Superheat	—	55° F.
18. Evaporation factor	1·05	1·167
19. Steam per hour, actual, lb.	33,000	7,629
20. Steam per hour from and at 212° F., lb.	34,600	8,900
21. Steam per hour from and at 212° F. per lb. of coal, lb.	4·6	2·88
22. Steam per hour from and at 212° F. per ton of steel, lb.	2,135	1,930
23. Steam per hour from and at 212° F. per sq. ft. of heating surface, lb.	2·54	2·13
24. Equivalent of (22) as coal at 9 lb. per lb., cwt.	2·1	1·92
25. Net coal consumption per ton of steel, cwt.	2·025	4·08
26. Percentage saving	51	32
27. Extraction efficiency $= \frac{T_1-T_2}{T_1-T_s} \times 100$ per cent	91	87
28. Total fan horse-power	131	63
29. Steam equivalent of fan power, lb.	1,840	882
30. (29) as percentage of total steam	5·3	9·9
31. Calculated evaporation per lb. of coal, lb.	4·6 with 82 per cent. producer efficiency.	2·88 with 74 per cent. producer efficiency.
32. Method of measuring evaporation	Steam meter	Tank and water meter

As a rule, it is much easier to obtain full test figures on gas plants, as the retort house is a self-contained unit, and it is therefore possible to isolate the feed water, fuel to producers, &c. In the case of steel plant, special arrangements have to be made for individual tests, as the feed system is common to other parts of the plant, and producers are arranged in one large battery feeding various types of furnaces.

Table III.—*Test Results from Waste Heat Boiler on m.v. "Woensdrecht" (Messrs. Van Ommeren).*

(Single-screw tanker fitted with M.A.N. four-stroke engine.)

1. Average engine, S.H.P.	1,850
2. Oil per S.H.P. hour	180 grammes = 0·4 lb.
3. Calorific value of oil	18,000 B.Th.U. net per lb.
4. Inlet temperature to boiler	806° F. (430° C.)*
5. Outlet temperature from boiler	437° F. (225° C.)*
6. Steam pressure, 120 lb. to 135 lb. per sq. in.	127½ lb. per sq. in.
7. Steam temperature	346° F. (175° C.)
8. Mean CO_2 in exhaust	7¾ per cent.
9. Excess air	100 per cent. (approx.)
10. Steam per hour, actual	1,660 lb.
11. Evaporation factor	1·12
12. Steam per hour from and at 212° F.	1,860 lb.
13. Steam per B.H.P. hour	1 lb.
14. Heating surface of boiler	730 sq. ft.
15. Steam per sq. ft. of heating surface	2·55 lb.
16. Services carried by boiler	Steering gear, 15 kW dynamo, general service pumps
17. Calculated steam per B.H.P. hour under the above conditions	1·03 lb.

* Taken by thermometer.

Some Possibilities of Waste Heat Recovery.

Steel Plants.—Where the whole of the steel plant is collected in one unit, the ideal of the "self-supporting works" is readily attainable; that is to say, by proper waste heat recovery together with full utilisation of surplus coke oven and blast-furnace gas, the works can operate on the coal used in the coke ovens only. Even the producer coal and resultant gas is replaced by an equivalent gas consisting of mixed blast-furnace and coke oven gas. The result is that the net coal consumption per ton of finished steel can be reduced in certain cases from about 65 cwt. to approximately 32 cwt. Taking a figure of 35 cwt. to allow a margin and to include small outside services, the saving of 30 cwt. at 12s. 6d. per ton means an economy on fuel alone of nearly 19s. per ton of finished steel. This fuel saving is accompanied by considerably reduced labour and handling charges. On a steel plant making 200,000 tons of steel per annum, a saving of £190,000 on fuel alone constitutes a very big item.

Carbonising Plants.—Practice has shown that the normal gasworks can meet the whole of its power and process requirements by means of waste heat steam, and in this instance it must be remembered that comparatively small power units, with consequent low efficiencies, are involved.

In the author's opinion, the electricity supply and the gasworks in every town should be interlinked and under one control, such an arrangement having many advantages. The general scheme would be to use all coke breeze, and any other coke not required for sale, in high-pressure boilers. Waste heat recovery would be employed at medium pressures, to obtain the best quantitative results, and the steam from the two sources would be combined in mixed-pressure turbines, or, alternatively, a system of high and medium-pressure turbines, "bleeding" low-pressure process steam. All works services would, of course, be electrified.

The gasworks of Great Britain carbonise some 16 million tons of coal per annum. Assuming that this coal uses 14 per cent. of its weight of coke for carbonisation, the total annual consumption of fuel coke is 2,240,000 tons. With settings properly arranged for waste heat recovery, 4 tons of steam per ton of coke would be an average figure to represent both modern vertical retort practice and modern regenerative horizontal retort practice. Therefore, nearly 9,000,000 tons of steam would be available. Before the advent of waste heat recovery practice, gasworks steam was generated from coke breeze at, say, 6 tons of steam per ton of breeze. Therefore, waste heat recovery adopted throughout our home works would represent 1,500,000 tons of coke breeze saved for other purposes. At 10s. per ton, this is equivalent to £750,000.

In dealing with both steel plants and carbonising plants, the subject of waste heat recovery is, of course, closely interlinked with the complementary subject of the effective utilisation of the steam. Each individual works has to be properly reviewed before the best all-round solution can be found. Low-pressure steam from turbines for process work, steam accumulators to balance supply and demand, and the elimination of small isolated heat engines as prime movers are among a number of salient features in this aspect of the subject.

In selecting steel plants and carbonising plants as two of the three main examples of the application of waste heat recovery, the author has included two of our greatest national users of coal; but the principles underlying waste heat recovery apply equally to all branches of industry involving heat processes, such as cement manufacture, brick and pottery manufacture, metallurgical works of all kinds, chemical works and so forth. The cement industry, in particular, has been a happy field for waste heat recovery practice; where the dry process is in operation, the waste gas conditions closely approximate to fuel firing practice, and the water-tube boiler has found extremely successful application. In the wet process, with waste gases at about 400 deg. Cent., or even less, the author's firm has successfully applied the fire-tube type of waste heat boiler.

An important problem in connection with waste heat recovery from the technical point of view, is that associated with steam generation in two stages. The advent of the big unit boiler fired with pulverised fuel and generating steam at a high initial pressure would appear to be best met by two-stage steam generation. The main boiler would be a high-pressure water-tube unit, designed chiefly for radiant heat absorption, and would be followed by a secondary boiler of waste heat design, operating at low pressure. The steam from this would be used for feed heaters, evaporators, de-gasifiers, &c., and any surplus would be used in the low-pressure stages of the turbines. The superheater would be interposed between the two